Complete Catalogue of all modules FB 18 Electrical Engineering and Information Technology (PO 2023)

Module handbook
FB 18
Date: 17.04.2026

TECHNISCHE
UNIVERSITÄT
DARMSTADT

FB 18

Module handbook: Complete Catalogue of all modules FB 18 Electrical Engineering and Information Technology (PO 2023)

Date: 17.04.2026

FB 18
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Contents

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1.1 Lectures

Module name System Dynamics and Automatic Control Systems II					
Module nr. 18-ad-1010	**Credit points** 7 CP	**Workload** 210 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1	**Teaching content** Main topics covered are: 1. Root locus method (construction and application), 2. State space representation of linear systems (representation, time solution, controllability, observability, observer- based controller design)
2	**Learning objectives** After attending the module, a student is capable of: 1. constructing and evaluating the root locus of given systems 2. describing the concept and importance of the state space for linear systems 3. defining controllability and observability for linear systems and being able to test given systems with respect to these properties 4. stating controller design methods using the state space, and applying them to given systems 5. applying the method of linearization to non-linear systems with respect to a given operating point
3	**Recommended prerequisites for participation** System Dynamics and Control Systems I
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 180 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, M.Sc. WI-etit, M.Sc. CE, M.Sc. MedTec, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit, M.Sc. etit - CMEE, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**

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

Courses

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

Module name Programming in Automatic Control (C/C++)					
Module nr. 18-ad-1020	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Rolf Findeisen		

1	**Teaching content** Makefiles, compiler, numeral systems and numeral representation, C programming: Structures in C (variables and types, functions and operators, structures and control loops), arrays and strings, pointer arithmetics, dynamic memory allocation, development environment and debugger; C ++: Concept of object-oriented programming, classes, operator overloading / function overwriting
2	**Learning objectives** Students can after successful completion of the module: 1. assembling and using makefiles, 2. working with different numeral systems and representations, 3. understanding and applying standard C tools (variables, functions, operators, control structures, arrays, strings), 4. explaining and implementing of pointers in C programming, 5. defining the memory requirement of variables during the runtime of the program (dynamic memory allocation) 6. explaining and using the concept of object oriented programming in C ++, working with abstract data types (classes).
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, M.Sc. CE, B.Sc. MedTec, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture slides

Courses

Course nr.	**Course name**		
18-ad-1020-vl	Programming in Automatic Control (C/C++)		
Instructor		**Type**	**SWS**
Dr. Ing. Eric Lenz		Lecture	1

	Course nr.	Course name		
	18-ad-1020-ue	Programming in Automatic Control (C/C++)		
	Instructor		**Type**	**SWS**
	Dr. Ing. Eric Lenz		Practice	1

Module name					
Module name Electrical Power Engineering					
Module nr. 18-bt-1010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Yves Burkhardt		

1 Teaching content

The lecture gives an introduction to the technical processes for the use of energy for the human civilization in general and to the basic tasks and challenges of the electrical energy in particular. Biochemical energy processes such as the human metabolism are therefore not subject of the course.
First, the physical basics of the term "energy" are repeated and the different forms of energy (mechanical, thermal, electromagnetic, chemical and nuclear) are explained in terms of the technical use of energy as heat, mechanical movement and electricity.
Then, an overview of the energy resources is given, starting from the solar radiation and its direct and indirect impact, such as the solar heat and the motion of air mass, surface water and sea waves. Next, the energy source of biomass due to solar radiation and the fossil energy sources oil, natural gas and coal will be discussed. The energy sources of nuclear fission (uranium deposits) and nuclear fusion (heavy water), and geothermal energy due to nuclear effects in the Earth's interior are explained as well as the tidal effects caused by planetary motion. The increasing energy demand of the rapidly growing world population and the geographic distribution of energy sources (deposits, acreage, solar radiation, wind maps, tidal currents, ...) are described.
The resulting energy flows on transport routes such as pipelines, waterways, ..., are briefly presented. In another section, energy conversion processes (direct and indirect methods) are illustrated. Large-scale processes such as thermal cycles or hydraulic processes in power plants are discussed mainly, but also marginal processes such as thermionic converters are addressed. Afterwards, a specialization takes place on the subject of electric power supply with respect to the increasing proportion of the electric power applications. The chain from the electric generator to the consumer with an overview of the required resources, the hiring electrical load flow and its stability is addressed. The storage of energy and in particular of electrical energy by converting into other forms of energy will be discussed. Finally, questions for the contemporary use of energy resources in regard to sustainability are mentioned.

2 Learning objectives

Students know the physically based energy basics and have an overview of the energy resources of our planet Earth.
They understand the fundamental energy conversion processes on the technical use of energy in the form of heat as well as mechanical and electrical work.
They have acquired basic knowledge of electrical engineering in the chain of effects from electric power producer to the consumer and are able to educate themselves about current issues of energy use and its future development.
They are able to perform basic calculations for energy content, energy conversion, efficiencies, storage, and for conversion and transportation losses. They are prepared for advanced lectures on energy components and systems, energy industry, and on future forms of energy supply.

3 Recommended prerequisites for participation

Basic knowledge of physics (mechanics, thermodynamics, electrical engineering, structure of matter) and chemistry (binding energy) are desirable and facilitate understanding of the energetic processes.

4 Form of examination

Module exam:

- Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

	Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, M.Sc. ESE, B.Sc. CE, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)** At the beginning of the semester, it will be announced whether there will be homework tests accompanying the lecture that will enable an improvement in grades.
9	**References** Lecture notes (slides) Practice documents (examples, solutions) Additional and more detailed literature: • Grothe/Feldhusen: Dubbel-Taschenbuch für den Maschinenbau, Springer, Berlin, 2007, 22. Aufl.; besonders: Kapitel „Energietechnik und Wirtschaft“ • Sterner/Stadler: Energiespeicher - Bedarf, Technologien, Integration, Springer-Vieweg, Berlin, 2011 • Rummich: Energiespeicher, expert-verlag, Renningen, 2015, 2. Aufl. • Strauß: Kraftwerkstechnik zur Nutzung fossiler, nuklearer und regenerativer Energiequellen, Springer, Berlin, 2006, 5. Aufl. • Hau: Windkraftanlagen -Grundlagen, Technik, Einsatz, Wirtschaftlichkeit, Springer-Vieweg, Berlin, 2014, 5. Aufl. • Heuck/Dettmann/Schulz: Elektrische Energieversorgung, Springer-Vieweg, Berlin, 2014, 9. Aufl. • Quaschning: Regenerative Energiesystem, Hanser, München, 2001, 7. Aufl.

Courses

Course nr.	Course name		
18-bt-1010-vl	Electrical Power Engineering		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Dr.h.c. Andreas Binder		Lecture	3
Course nr.	**Course name**		
18-bt-1010-ue	Electrical Power Engineering		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Dr.h.c. Andreas Binder		Practice	1

Module name Electrical Machines and Drives					
Module nr. 18-bt-1020	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Yves Burkhardt		

1	**Teaching content** Construction and function of induction machine, synchronous machine, direct current machine. Electromagnetic field within machines, armature windings, steady-state performance as motor/generator, application as line-fed and inverter-fed drives. Significance for electric power generation, both to the grid and in stand-alone version.
2	**Learning objectives** Upon successful completion of the module, students will be able to: • calculate and explain the stationary operation performance of the three basic types of electric machine sin motor and generator mode, • understand the application of electrical machines in modern drive systems and to design simple drive applications by yourself, • understand and explain the function and physical background of the components of electrical machines • understand and explain the impact of basic electromagnetic field and force theory on the basic function of electrical machines.
3	**Recommended prerequisites for participation** Mathematics I to III, Electrical Engineering and Information Technology I and II, Physics, Mechanical Engineering
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, M.Sc. ESE, M.Sc. etit - SAE, M.Sc. etit - EET, B.Sc. CE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)** At the beginning of the semester, it will be announced whether there will be short tests accompanying the lecture that will enable an improvement in grades.
9	**References**

- Detailed textbook and collection of exercices; Complete set of PowerPoint presentations
- A. Binder: El. Maschinen u. Antriebe: Grundlagen, Betriebsverhalten, Springer Vieweg, 2017
- A. Binder: El. Maschinen u. Antriebe: Übungsbuch, Springer Vieweg, 2017
- E. Bolte: Elektrische Maschinen, Springer Vieweg, 2018
- R. Fischer: Elektrische Maschinen, Carl Hanser Verlag, 2017
- J. Pyrhönen, T. Jokinen, V. Hrabovcova: Design of Rotating Electrical Machines, 2013, Wiley
- G. Müller, B. Ponick: El. Maschinen: 1: Grundlagen, 2014; 2: Berechnung, 2007, Wiley-VCH
- Th. Bödefeld, H. Sequenz: Elektrische Maschinen, Springer Vieweg, 1971
- H.-O. Seinsch: Grundlagen el. Maschinen u. Antriebe, Springer Vieweg, 1993

Courses

Course nr.	Course name	Instructor	Type	SWS
18-bt-1020-vl	Electrical Machines and Drives	Prof. Dr.-Ing. Yves Burkhardt	Lecture	2
18-bt-1020-ue	Electrical Machines and Drives	Prof. Dr.-Ing. Yves Burkhardt	Practice	2

Module name Foundations of Precision Engineering					
Module nr. 18-bu-1010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Ph.D. Thomas Burg		

1	**Teaching content** Precision engineering enables the repeatable integration of microelectronic and mechanical components with sensors and actuators to create dense and complex electromechanical systems. The applications range from mass products such as smartphones or cars to precision prototypes in medical technology, spaceflight, and scientific instrumentation. The course introduces the principles of design and manufacturing for precision with critical dimensions in the micrometer to millimeter range. Manufacturing methods including casting, molding, sintering, 3D printing, forming, cutting, etching, and joining will be explained. The properties, composition, and modifications of materials (metals and alloys, ceramics, polymers, composites) will be discussed in the context of key manufacturing processes.
2	**Learning objectives** To be able to classify and explain the most important maufacturing technologies, and to critically assess their respective advantages and disadvantages. To select suitable manufacturing technologies and to design for their application. To make quantitative estimates of the limitations of a given process and to evaluate the potential of new developments based on your knowledge of physical principles and materials.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If enrollment is expected to be less than 6 students, the examination will be an oral examination (duration: 30 min.). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, M.Sc. MEC, B.Sc. CE, M.Sc. MedTec, M.Sc. iCE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture notes, Moodle course

Courses

Course nr.	Course name		
18-bu-1010-vl	Technology of Micro- and Precision Engineering		
Instructor		**Type**	**SWS**
Prof. Ph.D. Thomas Burg		Lecture	2

	Course nr. 18-bu-1010-ue	**Course name** Foundations of Precision Engineering		
	Instructor Prof. Ph.D. Thomas Burg		**Type** Practice	**SWS** 1
	Course nr. 18-bu-1010-pr	**Course name** Foundations of Precision Engineering Lab		
	Instructor Prof. Ph.D. Thomas Burg		**Type** Lab	**SWS** 1

Module name					
Mechanics in Biomedical Engineering					
Module nr. 18-bu-1030	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Ph.D. Thomas Burg		

1	**Teaching content** Statics: force, moment, principle of section, equilibrium, center of gravity, truss, beam, adhesion and friction, levers. Elastomechanics: Stress and deformation, tension, torsion, bending. Kinematics: point and rigid body motion, forward kinematics Inverse kinematics. Kinetics: forces and moments theorem, energy and work, linear oscillators, momentum and twist theorem, impact. Biomechanics: mechanical properties of muscles, tendons; muscle-tendon dynamics in selected motion tasks (e.g., jumping, walking, running), inherent dynamics of human gait. Bioinspired robotics: fundamentals of mechanical design and dynamics of engineered systems (e.g., walking robot and assistance system).
2	**Learning objectives** Upon successful completion of the module, students will have learned the basic concepts of engineering mechanics. They will be able to analyze simple statically determinate plane systems of statics, perform elementary elastomechanics calculations of statically determinate and statically indeterminate structures, describe and analyze motion processes, and solve plane motion problems, vibration and impact phenomena using the laws of kinetics. Students have learned to describe human motion mechanically and to derive dynamic models for motion analysis and synthesis and to transfer these to technical applications (e.g. walking robotics, prosthetics and assistance systems).
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References**

- Markert, Norrick: Einführung in die Technische Mechanik, ISBN 978-3-8440-3228-4

The practice exercises are included in this book.
Further reading:

- Markert: Statik - Aufgaben, Übungs- und Prüfungsaufgaben mit Lösungen, ISBN 978-3-8440-3279-6
- Markert: Elastomechanik - Aufgaben, Übungs- und Prüfungsaufgaben mit Lösungen, ISBN 978-3-84403280-2
- Markert: Dynamik - Aufgaben, Übungs- und Prüfungsaufgaben mit Lösungen, ISBN 978-3-8440-2200-1 Gross, Hauger, Schröder, Wall: Technische Mechanik 1 - 3. Springer-Verlag Berlin (2012-2014).
- Hagedorn: Technische Mechanik, Band 1 - 3. Verlag Harri Deutsch Frankfurt.
- Enoka: Neuromechanics of Human Movement
- McMahon: Muscle, Reflexes and Locomotion
- Sharbafi & Seyfarth: Bioinspired Legged Locomotion
- Spong, Hutchinson, Vidyasagar: Robot Dynamics and Control

Courses

Course nr.	Course name	Instructor	Type	SWS
18-bu-1030-vl	Mechanics in Biomedical Engineering	Prof. Ph.D. Thomas Burg	Lecture	2
18-bu-1030-ue	Mechanics in Biomedical Engineering	Prof. Ph.D. Thomas Burg	Practice	1

Module name Introduction to Electrodynamics					
Module nr. 18-dg-1010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Teaching content** Vector calculus, orthogonal coordinate systems, Maxwell's equations, interface and boundary conditions, layered media, electrostatics, scalar potential, Coulomb integral, separation of variables, method of image charges, magnetostatics, vector potential, Biot-Savart law, stationary current fields, fields in matter, energy flow, skin effect, plane waves, polarization, TEM waves, reflection and multi-layer problems, multi conductor transmission lines (capacitance, inductance, and conductance matrix), velocity definitions, basics of rectangular waveguides.
2	**Learning objectives** Students will be familiar with Maxwell's equations in integral and differential form for static and dynamic field problems. They will have a mental picture of wave phenomena in free space. They are able to recognice and interpret wave effects in the different areas of electrical engineering. They are able to derive the wave effects from Maxwell's equations and have a good understanding of the necessary mathematical tools.
3	**Recommended prerequisites for participation** Lecture notes. Further literature recommendations are given in the course.
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, B.Sc. CE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)** Improvement by up to 0.4 due to bonus points which can be acquired by means of e-learning online tests.
9	**References** Lecture notes. Further literature recommendations are given in the course.

Courses

Course nr.	**Course name**	**Instructor**	**Type**	**SWS**
18-dg-1010-vl	Introduction to Electrodynamics	Prof. Dr.-Ing. Herbert De Gersem	Lecture	2
18-dg-1010-ue	Introduction to Electrodynamics	Prof. Dr.-Ing. Herbert De Gersem	Practice	2

	Course nr. 18-dg-1010-tt	Course name Introduction to Electrodynamics		
	Instructor Prof. Dr.-Ing. Herbert De Gersem		**Type** Tutorial	**SWS** 1

Module name Finite Integration Technique					
Module nr. 18-dg-1030	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Teaching content** Basics FIT, electrostatics, magnetostatics, magnetoquasistatics, high frequency simulations, convergence studies, discretisation, time- and frequency domain simulations.
2	**Learning objectives** Students learn the basic concepts of the Finite Integration Technique (FIT) for the numerical solution of Maxwell's equations. Students are, furthermore, introduced to the practical application of the method for numerical field problems.
3	**Recommended prerequisites for participation** Basics of Maxwell's equations, linear algebra. Recommended: Basic knowledge in knowledge in "Technical Electrodynamics"
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. CE, M.Sc. iCE, M.Sc. etit - CMEE
8	**Grade bonus compliant to §25 (2)**
9	**References** Course notes, lecture slides.

Courses

Course nr.	**Course name**		
18-dg-1030-vl	Finite Integration Technique		
Instructor		**Type**	**SWS**
Dr.-Ing. Wolfgang Ackermann		Lecture	2

Module name					
Applications of Electrodynamics					
Module nr. 18-dg-1040	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Teaching content** Vector calculus, Maxwell's equations, electrostatics, magnetostatics, fields of stationary currents, electromagnetic waves and ultrasonic waves, analytical and numerical calculation techniques, wave propagation, reflection and transmission, diffraction, interference and polarization, applications of electromagnetic and ultrasonic waves in medical technology
2	**Learning objectives** The students get knowledge and intuition on electromagnetic fields and wave propagation phenomena. They are able to recognize and calculate field and wave phenomena in an electrical engineering context. They are familiar with the required mathematical tools. The students have a feeling for the application of electromagnetic fields and waves in medical engineering.
3	**Recommended prerequisites for participation** "Elektrotechnik und Informationstechnik II" (18-gt-1020), "Mathematics II" (04-00-0109), and "Mathematics III" (04-00-0111)
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture slides can be downloaded. Further references will be given in the lecture.

Courses

Course nr.	Course name	Instructor	Type	SWS
18-dg-1040-vl	Applications of Electrodynamics	Prof. Dr.-Ing. Herbert De Gersem	Lecture	2
18-dg-1040-ue	Applications of Electrodynamics	Prof. Dr.-Ing. Herbert De Gersem	Practice	2

Module name					
Technical Electrodynamics					
Module nr. 18-dg-1070	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Teaching content** Fields in materials, Green's functions, separation of variables in generalized orthogonal coordinates, conformal mapping, elliptic integrals and elliptic functions, electromagnetic forces, quasi-stationary fields, general waveguides, resonators, antennas.
2	**Learning objectives** Starting with Maxwell´s equations the lecture´s aim is to provide a general understanding of electromagnetic phenomena. Students will be able to apply analytical methods to simple problems. Students will exhibit the ability to deal with more complex electromagnetic formulations and tasks.
3	**Recommended prerequisites for participation** Vector analysis, infinitesimal calculus, basics in differential equations. Knowledge of "Introduction to Electrodynamics"
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 180 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, M.Sc. WI-etit, M.Sc. CE, B.Sc. WI-etit, M.Sc. etit - CMEE
8	**Grade bonus compliant to §25 (2)**
9	**References** Course notes available (including references)

Courses

Course nr.	Course name	Instructor	Type	SWS
18-dg-1070-vl	Technical Electrodynamics	Prof. Dr.-Ing. Herbert De Gersem, Dr.-Ing. Wolfgang Ackermann	Lecture	2
18-dg-1070-ue	Technical Electrodynamics	Prof. Dr.-Ing. Herbert De Gersem, Dr.-Ing. Wolfgang Ackermann	Practice	2
18-dg-1070-tt	Technical Electrodynamics	Prof. Dr.-Ing. Herbert De Gersem, Dr.-Ing. Wolfgang Ackermann	Tutorial	1

<table>
<tr><td colspan="6">Module name
Introduction to Physical Modelling</td></tr>
<tr><td>Module nr.
18-dg-1080</td><td>Credit points
6 CP</td><td>Workload
180 h</td><td>Self-study
120 h</td><td>Module duration
1 Term</td><td>Module cycle
Summer term</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr.-Ing. Herbert De Gersem</td></tr>
</table>

<table>
<tr><td>1</td><td>Teaching content
Physical modelling: Principles
Classification of physical model types (system, network, field models)
Type classification of physical models (elliptic, parabolic, hyperbolic) + Examples from electrical engineering and mechanics
Formulations, continuity equation, energy conservation, variational formulation, multiphysics settings
Computer Aided Design and Computer Aided Engineering: Approach and workflow
Modelling of engineering problems, modelling assumptions and errors
Mathematical modeling: discretization errors, algorithmic errors
Definition of quantities of interest, postprocessing
Design and optimization</td></tr>
<tr><td>2</td><td>Learning objectives
The students learn to formulate an electrical engineering design task as a physical problem, and then to transfer it into a mathematical model.</td></tr>
<tr><td>3</td><td>Recommended prerequisites for participation
Electrical Engineering and Information Technology I/II, Introduction to data-based modeling, Mathematics I/II/III, Statistics/Probability Theory, Scientific Computing, Physics</td></tr>
<tr><td>4</td><td>Form of examination
Module exam:
Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)</td></tr>
<tr><td>5</td><td>Prerequisite for the award of credit points
Passing the final module examination</td></tr>
<tr><td>6</td><td>Grading
Module exam:
Module exam (Technical examination, Oral examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td>Usability of the module
B.Sc. etit, B.Sc. CE, B.Sc. WI-etit</td></tr>
<tr><td>8</td><td>Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td>References</td></tr>
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<tr><td colspan="4">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-dg-1080-vl</td><td colspan="2">Course name
Introduction to Physical Modelling</td></tr>
<tr><td>Instructor
Prof. Dr.-Ing. Herbert De Gersem</td><td>Type
Lecture</td><td>SWS
2</td></tr>
</table>

	Course nr. 18-dg-1080-ue	**Course name** Introduction to Physical Modelling		
	Instructor Prof. Dr.-Ing. Herbert De Gersem		**Type** Practice	**SWS** 1
	Course nr. 18-dg-1080-pr	**Course name** Introduction to Physical Modelling		
	Instructor Prof. Dr.-Ing. Herbert De Gersem		**Type** Lab	**SWS** 1

Module name System Dynamics and Automatic Control Systems I					
Module nr. 18-fi-1010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Rolf Findeisen		

1	**Teaching content** Description and classification of dynamic systems; Linearization around an equilibrium point; Stability of dynamic systems; Frequency response; Linear time-invariant closed-loop systems; Controller design; Control structure optimization
2	**Learning objectives** Students will know how to describe and classify different dynamic systems. They will be able to analyse the dynamic behaviour in time and frequency domain. The students will be able to design controllers for linear time invariant systems.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, M.Sc. CE, B.Sc. MedTec, B.Sc. CE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit, M.Sc. etit - CMEE
8	**Grade bonus compliant to §25 (2)**
9	**References** • Skript Konigorski: "Systemdynamik und Regelungstechnik I", Aufgabensammlung zur Vorlesung, Lunze: "Regelungstechnik 1: Systemtheoretische Grundlagen, Analyse und Entwurf einschleifiger Regelungen", • Föllinger: "Regelungstechnik: Einführung in die Methoden und ihre Anwendungen", • Unbehauen: "Regelungstechnik I:Klassische Verfahren zur Analyse und Synthese linearer kontinuierlicher Regelsysteme, Fuzzy-Regelsysteme", Föllinger: "Laplace-, Fourier- und z-Transformation", • Jörgl: "Repetitorium Regelungstechnik", • Merz, Jaschke: "Grundkurs der Regelungstechnik: Einführung in die praktischen und theoretischen Methoden", • Horn, Dourdoumas: "Rechnergestützter Entwurf zeitkontinuierlicher und zeitdiskreter Regelkreise", • Schneider: "Regelungstechnik für Maschinenbauer", • Weinmann: "Regelungen. Analyse und technischer Entwurf: Band 1: Systemtechnik linearer und linearisierter Regelungen auf anwendungsnaher Grundlage"
Courses	

	Course nr. 18-fi-1010-vl	**Course name** System Dynamics and Automatic Control Systems I		
	Instructor Prof. Dr.-Ing. Rolf Findeisen, M.Sc. Florian Weigand, M.Sc. Roland Schurig		**Type** Lecture	**SWS** 3
	Course nr. 18-fi-1010-tt	**Course name** System Dynamics and Automatic Control Systems I- Auditorium Exercise		
	Instructor Prof. Dr.-Ing. Rolf Findeisen, M.Sc. Florian Weigand, M.Sc. Roland Schurig		**Type** Tutorial	**SWS** 1

Module name					
Principles of Optics for Medical Engineering					
Module nr. 18-fr-1010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. habil. Torsten Frosch		

1	**Teaching content** Recapitulation of electromagnetic waves, electromagnetic and polarization optics, ray optics, optical systems, wave optics, interference, diffraction, Fourier optics, optical waveguides and fibers, photon optics, photon-atom interactions, introduction to light-matter interactions, atomic and molecular structure, absorption, scattering, fluorescence, resonator optics, lasers, photodetectors, principles of laser spectroscopy
2	**Learning objectives** Students will learn the fundamental of optics and optical systems. At the end of the course, students will understand the basics of light-matter interactions and on this basis the working principles of lasers and of some spectroscopic techniques. Using this knowledge, they will be able to understand common methods and instruments used in optical medical engineering. This module is intended as introduction for subsequent lectures on optical medical engineering.
3	**Recommended prerequisites for participation** Mathematics I and II for electrical engineering, physics for electrical engineering
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS) The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 20 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	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. CE, B.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** • Bahaa E. A. Saleh und Malvin Carl Teich, Optik und Photonik, Wiley • Eugen Hecht, Optik, Oldenburg Verlag • Frank L. Pedrotti, Leno S. Pedrotti, Werner Bausch, Hartmut Schmidt, Optik für Ingenieure, Springer • Herman Haken, Hans Christoph Wolf, Atom- und Quantenphysik, Springer • Herman Haken, Hans Christoph Wolf, Molekülphysik und Quantenchemie, Springer • Peter W. Atkins, Julio de Paula, Michael Bär, Physikalische Chemie, Wiley • Wolfgang Demtröder, Laserspektroskopie 1&2, Springer
Courses	

	Course nr.	Course name		
	18-fr-1010-iv	Principles of optics for medical engineering		
	Instructor		**Type**	**SWS**
	Prof. Dr. habil. Torsten Frosch		Integrated course	4

Module name Power Electronics					
Module nr. 18-gt-1010	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1	**Teaching content** Power electronic devices convert the energy from the distribution network to the form required by the load. This conversion does not wear out, can be controlled very fast and has a high efficiency. In lecture “Power Electronics“ the most important circuits required for the energy conversion are treated, using ideal switches. The main chapters are I.) Line commutated converters in order to understand the basic concepts of power electronic systems. II.) Self- commutated converters (one, two and four quadrant converters, 3-phase- VSI)
2	**Learning objectives** The module teaches students after successful completion: • Understand the ideal concept of power semiconductors • Calculate and sketch the time-characteristics of all currents and voltages in a line-commutated converter using defined simplifications as well as represent the behavior of currents and voltages during commutation in line-commutated converters for center -tapped as well as for bridge circuits. • Specify the basic circuit diagrams for one, two and four quadrant DC/DC converters and calculate the characteristics of voltages and currents in these circuits. • Explain the function of single-phase and three-phase voltage source inverters and calculate the currents and voltages in these circuits using defined simplifications. • Understannd the concept und operation of HVDC converter
3	**Recommended prerequisites for participation** Mathe I und II, ETiT I und II, Energietechnik
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, M.Sc. etit - EET, M.Sc. etit - AUT, B.Sc. CE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Lecture notes, instructions for exercises are available for download in Moodle.
Literature:

- Probst U.: „Leistungselektronik für Bachelors: Grundlagen und praktische Anwendungen“, Carl Hanser Verlag GmbH & Co. KG, 2011
- Jäger, R.: „Leistungselektronik: Grundlagen und Anwendungen“, VDE-Verlag; Auflage 2011
- Heumann, K.: „Grundlagen der Leistungselektronik“; Teubner; Stuttgart; 1985
- Lappe, R.: „Leistungselektronik“; Springer-Verlag; 1988
- Mohan, Undeland, Robbins: Power Electronics: Converters, Applications and Design; John Wiley Verlag; New York; 2003

Courses

Course nr.	**Course name**		
18-gt-1010-vl	Power Electronics		
Instructor		**Type**	**SWS**
M.Sc. Lars Dresel, M.Sc. Zhaoqing Zhang, Prof. Dr.-Ing. Gerd Griepentrog		Lecture	2

Course nr.	**Course name**		
18-gt-1010-ue	Power Electronics		
Instructor		**Type**	**SWS**
M.Sc. Milad Khani, M.Sc. Lars Dresel, Prof. Dr.-Ing. Gerd Griepentrog		Practice	2

Module name Electrical Engineering and Information Technology II					
Module nr. 18-gt-1020	**Credit points** 7 CP	**Workload** 210 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1	**Teaching content** Electrostatic fields; stationary electrical flow fields; stationary magnetic fields; temporally variable magnetic fields; capacitor networks, transmission lines
2	**Learning objectives** Upon successful completion of the module the students have detached themselves from the conception that all electrical procedures are line-bound; they have a clear idea of the field term, can read and interpret field plots and also design simple field plots themselves; they understand the difference between a curl and a divergence field, can describe this difference mathematically and are able to recognize the field type from a mathematical description, respectively; they are able to calculate field distributions for simple rotationally symmetric arrangements analytically; they can deal surely with the definitions of the electrostatic, the electrical quasi-static, the magnetostatic and the magneto-electric field; they have recognized the connection and dualism of electricity and magnetism; they control the mathematical apparatus necessary for their description and can apply it to simple examples; they can calculate with nonlinear magnetic circuits; they can compute inductance, capacity and resistance of simple geometrical arrangements and understand them now as physical characteristics of the respective arrangement; they have recognized, how different forms of energy can be transferred into each other and are thereby already able to solve simple scientific engineering problems; they have understood the underlying physical backgrounds for many applications of electrical engineering and are able to describe them mathematically, develop it further in a simple way and apply it to other examples; they are familiar with the system of Maxwell's equations in their integral representation have a first idea of the importance of Maxwell's equations for all conceptual formulations of electrical engineering. They understand the propagation of electromagnetic waves in the free space and on transmission lines for both harmonic ans transient signals.
3	**Recommended prerequisites for participation** Electrical Engineering and Information Technology I
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, B.Sc. MedTec, B.Sc. CE, B.Sc. iST, B.Ed. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)** Notenverbesserung entsprechend 25 (2) APB TU Darmstadt
9	**References**

	• Downloadable slides • Clausert, Wiesemann, Hinrichsen, Stenzel: „Grundgebiete der Elektrotechnik I und II"; ISBN 978-3-486-59719-6 • Prechtl, A.: „Vorlesungen über die Grundlagen der Elektrotechnik - Band 2" ISBN: 978-3-211-72455-2

Courses

	Course nr. 18-gt-1020-vl	**Course name** Electrical Engineering and Information Technology II		
	Instructor Prof. Dr.-Ing. Gerd Griepentrog		**Type** Lecture	**SWS** 3
	Course nr. 18-gt-1020-ue	**Course name** Electrical Engineering and Information Technology II		
	Instructor M.Sc. Daniel Großmann, Prof. Dr.-Ing. Gerd Griepentrog		**Type** Practice	**SWS** 2

Module name Medical Systems					
Module nr. 18-ha-1010	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Christoph Hoog Antink		

1	**Teaching content** The human body, diseases and therapy from an engineering perspective:Systems theory view & modeling of physiological processes • Disease as disturbed control circuits, therapy as restoration of disturbed control circuits • Circulation and blood pressure in equivalent circuits and control loops • Biopotentials: origin, measurement, signal processing and classification • Bioimpedance analysis, bioimpedance spectroscopy, electrical impedance tomography • Effects of electrical current on biological tissue & electrical safety • Modeling of the lung & lung function diagnostics • Physiological temperature control and heat therapy • Organ replacement therapy (diabetes, cardiac support systems)
2	**Learning objectives** Students will have the ability to use fundamental engineering skills learned in other classes to understand healthy and diseased physiological processes as well as diagnosis and therapy. Students will be able to understand the basic principles of human anatomy and physiology using equivalent circuit diagrams and models. Students will know the effect of electric current on biological tissue and the basics of protection mechanisms. They know the basics of biopotential acquisition and bioimpedance measurement techniques. Through in-depth training in the field of electromedicine, students gain knowledge of the development of medical measurement and instrumentation technology. In addition, they master basic skills to apply control engineering methods to physiological control loops.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 20 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. MedTec, B.Sc. CE
8	**Grade bonus compliant to §25 (2)**
9	**References**

	• Leonhardt, Steffen, and Marian Walter, eds. Medizintechnische Systeme: Physiologische Grundlagen, Gerätetechnik und automatisierte Therapieführung. Springer-Verlag, 2016. (in German, available as free eBook from within the TU-network) • Silbernagl, Stefan, and Agamemnon Despopoulos. Taschenatlas Physiologie. Georg Thieme Verlag, 2007. (in German)

Courses

Course nr.	Course name		
18-ha-1010-vl	Medical Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christoph Hoog Antink		Lecture	2

Module name					
Computer Systems I					
Module nr. 18-hb-1020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Christian Hochberger		

1	**Teaching content** Types of instruction sets, memory organization and its impact on the runtime, pipelining, instruction level parallelism, superscalar processors, VLIW processors, floating point numbers and operations, memory subsystem, cache types, virtual address spaces, benchmarking and performance prediction, system architecture and bus systems, peripheral devices
2	**Learning objectives** Upon successful completion of the module, students can analyze and evaluate processors, memory systems and bus systems. They can transform structures of high-level programming languages like subroutine calls into sequences of machine instructions. They are able to measure the performance of computers. They know how instructions are executed in modern processors and thus, they can predict the influence of a specific memory hierarchy onto the execution time of a given program. They know how internal and external bus systems work and can define the essential parameters for their dimension and operation.
3	**Recommended prerequisites for participation** Basic knowledge of digital design as it can be obtained by the lecture "Logic Design".
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, M.Sc. WI-etit, M.Sc. etit - AUT, B.Sc. CE, B.Sc. iST, B.Ed. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** • Harris & Harris: Digital Design and Computer Architecture • Hennessy/Patterson: Computer architecture - a quantitative approach

Courses

Course nr.	Course name		
18-hb-1020-vl	Computer Systems I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Lecture	3

	Course nr. 18-hb-1020-ue	Course name Computer Systems I		
	Instructor Prof. Dr.-Ing. Christian Hochberger		Type Practice	SWS 1

Module name Electronics					
Module nr. 18-ho-1010	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1 Teaching content

Semiconductor Devices: Diode, MOSFET, Bipolar Transistor; Design of Electronic Circuits;
Analog Circuits: Basic Properties, Properties and Application of Operational Amplifiers, Circuit Simulation with SPICE, Small Signal Gain, Single Stage Amplifiers; Frequency Response;
Digital Circuits: CMOS Logic Circuits

2 Learning objectives

A student is, after successful completion of this module, able to

1. analyse Diodes, MOS- und Bipolartransistors in simple circuits
2. calculate the properties of single transistor circuits, such as small signal gain, input and output resistance
3. design inverting and non-inverting amplifiers from operational amplifiers and knows their ideal and non-ideal properties
4. calculate the frequency behavior of simple transistor circuits
5. distinguish the different methods to construct a logical gate from basic transistors and explain their fundamental properties.

3 Recommended prerequisites for participation

Basics of Electrical Engineering

4 Form of examination

Module exam:
- Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

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

7 Usability of the module

B.Sc. etit, B.Sc. MEC, B.Sc. MedTec, B.Sc. CE, B.Sc. iST, B.Ed. etit, B.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

A grade improvement of up to 0,4 due to a bonus is possible, which can be earned with tests.

9 References

Lecture Slide Copies; Richard Jaeger: Microelectronic Circuit Design

Courses

Course nr.	Course name		
18-ho-1011-vl	Electronics		
Instructor		**Type**	**SWS**
M.Sc. Oliver Bachmann, Prof. Dr.-Ing. Klaus Hofmann		Lecture	2

	Course nr.	Course name		
	18-ho-1011-ue	Electronics		
	Instructor		**Type**	**SWS**
	M.Sc. Oliver Bachmann, Prof. Dr.-Ing. Klaus Hofmann		Practice	1

Module name Electronic and Integrated Circuits					
Module nr. 18-ho-1020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1 Teaching content

Basic analog Building Blocks: Current- and Voltage sources, Stabilizing circuits, Current Mirrors, Reference Circuits; Multi Stage Amplifier, internal Structure and Properties of Differential and Operational Amplifiers, Feedback Techniques, Frequency Response, Clock Generation and Oscillators

2 Learning objectives

A student is, after successful completion of this module, able to

1. derive the fundamental properties of the MOS-Transistors from knowledge of the layout or fabrication process,
2. derive fundamental MOSFET-circuits (current source, voltage source, current mirror, switch, active resistors, inverting amplifiers, differential amplifiers, output amplifiers, operational amplifiers, comparators) and knows their fundamental properties (y-Parameters, DC- and AC-properties),
3. understands simulation methods for analog circuits on transistor level using SPICE,
4. analyze feedback amplifiers regarding frequency gain, stability, bandwidth, root locus, amplitude and phase-margin,
5. Analyze electronic circuits for voltage and current provision,
6. Analyze basic circuits for clock/waveform generation

3 Recommended prerequisites for participation

Lecture "Electronics"

4 Form of examination

Module exam:
- Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

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

7 Usability of the module

B.Sc. etit, B.Sc. MEC, M.Sc. MEC, M.Sc. CE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

A grade improvement of up to 1,0 due to a bonus is possible, which can be earned with tests.

9 References

Lecture Slide Copies; Richard Jaeger: Microelectronic Circuit Design

Courses

Course nr.	**Course name**		
18-ho-1020-vl	Analog Integrated Circuit Design		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Lecture	3

	Course nr.	Course name		
	18-ho-1020-ue	Analog Integrated Circuit Design		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Klaus Hofmann		Practice	1

Module name					
Advanced Topics in PCB Design					
Module nr. 18-ho-1110	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Teaching content** Printed circuit board (PCB) layout, PCB stackups, PCB recycling, reliability
2	**Learning objectives** After attending the lecture and exercise students are able to layout multilayer printed circuit boards (PCBs) based the requirements of the circuit's schematic. Students know how PCBs are manufactured and how manufacturing affects the layout. They have mastered the design rules for rigid, rigid-flex and flex PCBs. They are well versed in the basics of: signal integrity for high-speed signals; PCB level EMI; recycling and circular economy for PCBs; PCB assembly and IC packaging; PCB reliability.
3	**Recommended prerequisites for participation** "Electronics" lecture, "Electronics" lab
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)** Possible, grade bonus up to 0,4 following 25 (2) APB for successful participation in the integrated lab. For a successful participation regular attendance (= 75 %) of the design reviews as well as the submission of a manufacturable PCB layout is required.
9	**References**

Courses

Course nr.	Course name	Instructor	Type	SWS
18-ho-1110-vl	Advanced Topics in PCB Design	Dr.-Ing. Ferdinand Keil	Lecture	2
18-ho-1110-ue	Advanced Topics in PCB Design	Dr.-Ing. Ferdinand Keil	Practice	1
18-ho-1110-pr	Advanced Topics in PCB Design	Dr.-Ing. Ferdinand Keil	Lab	1

Module name					
Elektrische Energieversorgung I / Power Systems I					
Module nr. 18-hs-1010	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1	**Teaching content** Three-phase network and symmetrical components; overhead lines; cables; transformers; calculation of short-circuit currents; switch equipment; switchgears
2	**Learning objectives** Upon completion of the module, students will have learned: • Presentation of components of power system • Functional elaboration of equipment • Calculation of the component rating • Impact on the electrical power system
3	**Recommended prerequisites for participation** comparable competences to the module "Power Engineering"
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 6 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	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, M.Sc. etit - EET, M.Sc. WI-etit, B.Sc. CE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Script, lecture slides, guiding questions, excercises

Courses

Course nr.	Course name	Instructor	Type	SWS
18-hs-1010-vl	Elektrische Energieversorgung I / Power Systems I	M.Sc. Felix Korff, Prof. Dr.-Ing. Jutta Hanson, M.Sc. Manuel Schwenke	Lecture	2
18-hs-1010-ue	Elektrische Energieversorgung I / Power Systems I	M.Sc. Felix Korff, Prof. Dr.-Ing. Jutta Hanson, M.Sc. Manuel Schwenke	Practice	2

Module name Electrical Engineering Systems					
Module nr. 18-hs-1100	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1	**Teaching content** The module covers the following content with focus on power engineering: • Advanced network theory: Common mode and differential mode, three-phase systems, four-pole theory. • Transients in time domain and in frequency domain: switching on and off processes, resonant circuits • Coupling of electrical and mechanical systems (mode of operation, equivalent circuit diagram, signal models): transformer, electrical machines • Electrical behavior of lines/line theory (steady state and transients)
2	**Learning objectives** The students know the steady-state and dynamic behavior of three-phase systems for selected equipment and are able to calculate this mathematically. They can describe the interaction of electrical and mechanical systems using the example of the transformer and electrical machines. The electrical behavior of lines is known. A basic understanding of switching operations in the electrical network is gained.
3	**Recommended prerequisites for participation** Electrical Engineering and Information Technology I (18-hs-1070), Electrical Engineering and Information Technology II (18-gt-1020), Deterministic Signals and Systems (18-kl-1010)
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, B.Sc. CE, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** • Lecture slides (download)

Courses

Course nr.	**Course name**		
18-hs-1100-vl	Electrical Engineering Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jutta Hanson		Lecture	2

	Course nr.	Course name		
	18-hs-1100-ue	Electrical Engineering Systems		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Jutta Hanson		Practice	1

Module name Fundamentals of Communication					
Module nr. 18-jk-1010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1	**Teaching content** **Part 1 Fundamentals of Signal Transmission:** Chap. 1 will be a brief introduction in "Electrical Information- and Communication Engineering", presenting signals as carrier of information, classifying electrical signals and describing elements of communication systems. Then, Chap. 2 introduces various line-conducted and wireless transmission media, power budget calculations for both media types, basics of antenna radiation and parameters etc., which will be emphasized by application examples like TV-satellite reception and mobile communication channels. Chap. 3 is focused on signal distortions and interferences, especially thermal noise, considering noisy two-port devices and its concatenations, lossy networks, antenna noise temperature and the impact of noise on analog and digital signals. This chap. ends with basics of information theory and channel capacity for AWGN-channels. In contrast, chap 4 deals with some fundamentals of noise-reduction and distortion-compensation techniques. **Part 2 Digital Baseband-Signal Processing:** Chap. 5 introduces sampling of band-limited signals and analog modulation of a pulse carrier (pulse-amplitude-, pulse-duration- and pulse-angle-modulation), which will be extended in chapter 6 on digital modulation in the baseband by means of pulse-code modulation (PCM), focusing on signal quantizing, analog-digital conversion, minimum bandwidth, bit error rate and error probability of a PCM word. At least, PCM-time-division multiplex and -systems will be discussed. Chap. 7 introduces band-limited inter-symbol interference-free transmission and matched filtering in the baseband. **Part 3 Analog Radio Frequency (RF) Signal Processing:** Chap. 8 deals with fundamentals of multiplex- and RF-modulation schemes as well as with frequency conversion, frequency multiplication and mixing strategies. Then, receiver principles and image frequency problems of heterodyne-receivers as well as amplitude modulation of a sinus carrier will close this chapter. Chap. 9 introduces digital modulation of a harmonic carrier, including binary shift keying of a sinusoidal carrier in amplitude (ASK), phase (PSK) or frequency (FSK) as well as higher-order modulation schemes like M-PSK and M-QAM. At the end, there will be a comparison of the bandwidth and power efficiency of these modulation schemes. Then in chapter 10, a brief outlook on the functionality of channel coding and interleaving is given in order to assess the performances of digital communication systems, which requires most of the learned content of this lecture.
2	**Learning objectives** **Aim of the Lecture:** To teach the fundamentals of communications (physical layer), primarily the transmission of signals from a source to a sink, possible modulation and access methods, signal distortion and noise as well as how to determine the performances of digital communication systems. The introduction of communications is a basement for further lectures like Communication Technology, Laboratories of Communication Technology (NTP A, B), Microwave Eng., Optical Communications and Mobile Communications.
3	**Recommended prerequisites for participation** Deterministic Signals and Systems
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading**

	Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, B.Sc. CE, B.Sc. iST, B.Ed. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Complete Script and Literature: • Pehl, E.: Digitale und analoge Nachrichtenübertragung, Hüthig Verlag • Meyer, Martin: Kommunikationstechnik, Vieweg • Stanski, B.: Kommunikationstechnik • Kammeyer, K.D.: Nachrichtenübertragung. B.G. Teubner • Mäusl, R.: Digitale Modulationsverfahren. Hüthig Verlag • Haykin, S.: Communication Systems. John Wiley • Proakis, J., Salehi M.: Communication Systems Engineering. Prentice Hall • Ziemer, R., Peterson, R.: Digital Communication. Prentice Hall • Cheng, D.: Field and Wave Electromagnetics, Addision-Wesley.

Courses

Course nr.	Course name		
18-jk-1010-vl	Fundamentals of Communications		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Jakoby		Lecture	3
Course nr.	**Course name**		
18-jk-1010-ue	Fundamentals of Communications		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Jakoby		Practice	1

Module name Microwave Engineering I					
Module nr. 18-jk-1020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1	**Teaching content** **Electromagnetic (EM) Properties of Materials:** 1.) Microscopic Scale, including energy levels and energy bands, charge carriers and conduction; 2.) Macroscopic Scale, including plane waves in homogeneous lossy media, electromagnetic properties of low-loss media (lossy dielectrics), skin effect in good conductive media (metals & alloys), penetration depth in biological tissues and specific absorption rate (SAR), oblique incidence of plane waves at a dielectric interface, mechanisms of polarization in dielectrics and its applications, losses in dielectrics, applications of (electro)ceramics; Interaction between Electromagnetic Waves and Biological Materials (Bioelectricity, Dielectric Dispersion in Tissues, Relaxation and Resonances, Microwave Dosimetry, SAR and thermal considerations, Exposure of Body to Cell Phone and Base Station) **Passive RF Circuits with R-, L- and C-Lumped Elements:** Resonant and Equivalent RLC Circuits, Graphical Representation of RF Circuits with the Smith Chart, Lumped-Element Impedance Matching. **Theory and Applications of Transmission Lines:** Propagation Modes in Transmission Lines, General Transmission-Line Equations (lumped-element model, transmission-line parameters, wave propagation along a transmission line); Wave Characteristics on Transmission Lines from input-port and output-port parameters of the line; Lossless Transmission Lines as Circuit Elements; Transmission-Line Terminations; Transmission-Line Impedance Matching, including quarter-wave transformer, impedance of a half-wave section and single-stub and double-stub matching; Left-Handed Metamaterial Lines and Dispersion. **Scattering-Matrix Formulation of Microwave Networks:** Scattering-Matrix Formulation; Characterization of Microwave Networks; Input and Output Reflections of Unmatched Microwave Networks; Concatenation and Transformations of Scattering Matrixes; ABCD-Matrix Formulation. ***N*-Port Microwave Devices:** Power Divider and Power Combiner: Three-Port Power Divider (Lossless T-junction Power Divider, Symmetrical, Resistive T-Junction Power Divider, Wilkinson Power Divider); Four-Port Power Divider (Coupled Line Directional Coupler, The Quadrature Hybrid, The 180°-Hybrid Coupler); In-plane N-Port Compound Devices with examples of Interference-based RF Switch and Butler Matrix. **Waveguides and Planar Transmission Lines:** Quasi-Optical Approach; General Solution from Maxwell´s Equations; Parallel-Plate Waveguide; Rectangular Waveguide; Attenuation in Waveguides (Dielectric Losses, Conductor Losses); Microstrip Lines.
2	**Learning objectives** Students understand the essentials of RF engineering: passive RF components and circuits with discrete elements and line components, line theory, application of scattering matrices to describe passive and active RF components, waveguides: theory, propagation and losses.
3	**Recommended prerequisites for participation** Communications engineering, fundamentals of technical electrodynamics
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination

<table>
<tr><td>6</td><td colspan="4">Grading
Module exam:
• Module exam (Technical examination, Examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td colspan="4">Usability of the module
B.Sc. etit, M.Sc. WI-etit, B.Sc. CE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit</td></tr>
<tr><td>8</td><td colspan="4">Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td colspan="4">References
Script is in English and will be ellectronically hand out at the beginning of the letcture; Literature will be recommended in first lecture</td></tr>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-jk-1020-vl</td><td colspan="3">Course name
Microwave Engineering I</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Rolf Jakoby</td><td>Type
Lecture</td><td>SWS
3</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-jk-1020-ue</td><td colspan="3">Course name
Microwave Engineering I</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Rolf Jakoby</td><td>Type
Practice</td><td>SWS
1</td></tr>
</table>

Module name High Voltage Technology I					
Module nr. 18-kc-1010	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Myriam Koch		

1	**Teaching content** Calculation of electrostatic fields, voltage distribution in insulating systems and layered dielectrics, field and potential control measures, breakdown of gases, surface discharge and pollution flashover, vacuum breakdown, generation and measurement of high voltages.
2	**Learning objectives** After participating in the module, students will be able to explain fundamental phenomena and principles related to high electric fields and they will be able to identify critical, highly stressed regions in electric field maps. They will be able to perform field optimizations through specific design of the dielectric materials and field-controlling geometries. They understand the various mechanisms that lead to failure of a gas-insulated systems, know which parameters affect their electrical strength, and can apply design criteria. They can identify weak points in the insulation system and propose improvements. They will be able to make an estimation of the breakdown or flashover voltage, respectively. Students will be able to identify regions with potential surface discharges and know how pollution flashover develops and how it can be avoided. Students will be able to explain the processes involved in vacuum breakdown and how it differs from gas breakdown. Furthermore, the students are able to explain the most important designs for high-voltage generators and to name suitable measuring equipment.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS) With up to 20 participants the examination will take place as an oral exam (duration: 30 min), otherwise as a written exam (duration: 120 min). The type of examination will be announced at the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, M.Sc. ESE, M.Sc. etit - EET, B.Sc. CE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)** Grade improvements up to 0.4 according to APB 25 (2) through bonus for successful participation in the internship.
9	**References** • Küchler, A.: High Voltage Technology, Springer • Beyer, M.; Boeck, W.; Möller, K.; Zaengl, W.: Hochspannungstechnik, Springer-Verlag
Courses	

	Course nr. 18-kc-1010-vl	**Course name** High Voltage Technology I		
	Instructor Prof. Dr. Myriam Koch, M.Sc. Manuel Philipp		**Type** Lecture	**SWS** 2
	Course nr. 18-kc-1010-ue	**Course name** High Voltage Technology I		
	Instructor Prof. Dr. Myriam Koch, M.Sc. Manuel Philipp		**Type** Practice	**SWS** 1
	Course nr. 18-kc-1010-pr	**Course name** High Voltage Technology I		
	Instructor Prof. Dr. Myriam Koch		**Type** Lab	**SWS** 1

Module name Deterministic Signals and Systems					
Module nr. 18-kl-1010	**Credit points** 7 CP	**Workload** 210 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Anja Klein		

1	**Teaching content** Examples of signals and systems, Specific signals, generalized functions, impulse function, step function, time represenation of signals and systems, linear time invariant systems, impulse response, convolution Fourier Series: Motivation; Fourier series with real coefficients; Fourier series with complex coefficients; properties of the Fourier series, convegence conditions, examples and applications Fourier Transform: Motivation - Deriviation from Fourier series - Dirichlet conditions - generalized functions, delta function - step function - properties of Fourier-transform - special cases - examples and applications,expansion into partial fractions Representation of signals and systems in frequency domain, Time invariant systems, convolutions theorem,-Parseval's theorem - properties-examples and applications Systems and Signals: Bandlimited and time limited systems - systems with only one energy store - examples and applications Laplace Transform: Motivation - single sided L-transform - inverse L-transform - theorems of L- transform - examples and applications Linear differential equations: Time invariant systems,equivalent circuits for passive electrical elements - examples and applications Discrete signals: series of numbers, relationship discrete and continuous signals, impulse sequence, step sequence, exponential sequence, periodicity in frequency and time. z-Transform: motivation, relationship to Laplace-Transform, definition one-sided z-Transform, convergence, examples and applications, properties of the z-Transform, discrete convolution, inverse z-Transform, partial fraction expansion. Discrete Systems: general description, properties, LTI systems, impulse response, step response, connection of systems, linear difference equations, discrete time and image area, transfer function, block diagrams, IIR- and FIR-systems. Signal Sampling and Reconstruction: ideal sampling and reconstruction in time and frequency domain, sampling theorem, practical aspects. Discrete-Time Fourier Transform (DTFT): motivation, relationship to Fourier-Transform, definition of DTFT, examples and applications, properties, inverse transform, system description via DTFT, Parseval‘s Theorem. Discrete Fourier Transform (DFT): motivation, relationship to DTFT, definition of DFT, examples and applications, properties, inverse transform, practical aspects, cyclic convolution.
2	**Learning objectives** The students should understand the principles of integral transformations and discrete transformations and be able to apply them to physical and technical problems. The students shall be able to mathematically describe and analyse continuous and discrete signals and systems (LTI) in time domain and in the corresponding image area. The techniques of this module are essential tools which will be needed in many follow-up modules.
3	**Recommended prerequisites for participation** Elektrotechnik und Informationstechnik I und Elektrotechnik und Informationstechnik II
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination

6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, M.Sc. CE, B.Sc. MedTec, B.Sc. CE, B.Sc. iST, B.Ed. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)** Yes, if not feasible in presence
9	**References** The slides of the lecture, documentation for the exercises and numerous additional documents will be provided in electronic form. Basic Literature: • A. Fettweis, Elemente nachrichtentechnischer Systeme, Teubner Verlag, 2. Auflage, Stuttgart/Leipzig, 1996. • S. Soliman and M.D. Srinath, Continuous and Discrete Signals and Systems, Prentice Hall, New Jersey, 1990. • T. Frey, M. Bossert, Signal- und Systemtheorie, Teubner Verlag, 2004 • H. Clausert, G. Wiesemann "Grundgebiete der Elektrotechnik 2", Oldenbourg, 1993. • Otto Föllinger "Laplace-, Fourier- und z-Transformation", Hüthig, 2003. • Exercises: • Hwei Hsu "Signals and Systems", Schaum's Outlines, 1995

Courses

Course nr.	Course name		
18-kl-1010-vl	Deterministic Signals and Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Anja Klein, Prof. Dr.-Ing. Marius Pesavento		Lecture	3
Course nr.	**Course name**		
18-kl-1010-ue	Deterministic Signals and Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Anja Klein, Prof. Dr.-Ing. Marius Pesavento, M.Sc. Maximilian Wirth		Practice	2

Module name Communication Technology I					
Module nr. 18-kl-1020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Anja Klein		

1	**Teaching content** Signals and Communication Systems, Base-band Communications, Detection of Base-band Signals in AWGN Channels, Bandpass-Signals und -Systems, Linear Digital Modulation Schemes, Digital Modulation und Detection, Multi-carier Transmission, OFDM, Spread-Spectrum Techniques, CDMA, Multiple Access
2	**Learning objectives** After completion of the module, students possess the ability to: • classify signals and communication systems, • understand, model and analyse basic components of communication systems, • understand, evaluate and compare communication systems for transmission over additive white Gaussian noise channels, • model and analyse base-band commnication systems, • describe and analyse bandpass signals and bandpass communication systems in the equivalent base-band, • understand, model, evaluate, compare and apply linear modulation schemes, • design receiver structures for different modulation schemes, • detect linear modulated data after transmission over additive white Gaussian noise channels in an optimum way, • understand and model OFDM, • understand and model CDMA, • understand and compare the basic properties of multiple access schemes.
3	**Recommended prerequisites for participation** Electrical Engineering I and II, Deterministische Signale und Systeme, Mathematics I to III, Statistics/Probability Theory, Scientific Computing
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, B.Sc. CE, M.Sc. iST, B.Ed. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be announced in the lecture
Courses	

	Course nr. 18-kl-1020-vl	**Course name** Communication Technology I		
	Instructor Prof. Dr.-Ing. Anja Klein		**Type** Lecture	**SWS** 3
	Course nr. 18-kl-1020-ue	**Course name** Communication Technology I		
	Instructor Prof. Dr.-Ing. Anja Klein, M.Sc. Wanja de Sombre, M.Sc. Bernd Simon		**Type** Practice	**SWS** 1

Module name Measurement Technology					
Module nr. 18-kn-1010	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Teaching content** Extent and Meaning of electrical measurement technology, units and measurement systems, description of measurement systems and signals, systematic and stochastic errors, relative and reduced errors, measurement uncertainty, analogue measurement of electrical parameter, power measurement in single- and three-phase systems, impedance measurements, use of oscilloscopes, measurement amplifier and filter, signal conversion (ADC, DAC), frequency and time measurements, data handling, digital data acquisition.
2	**Learning objectives** Students know the configuration and properties of electric and electronic measurement equipment and circuits and are able to apply them to measurement tasks. They know the basics of data aquisition, handling, transmission and storage and are able to describe and quantify measurement errors.
3	**Recommended prerequisites for participation** ETiT I & II, Mathematics I-III
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, B.Sc. MedTec, B.Sc. CE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Slides, Textbook Lerch: “Elektrische Messtechnik”, Springer

Courses

Course nr.	Course name	Instructor	Type	SWS
18-kn-1011-vl	Measuring Technique	Prof. Dr. Mario Kupnik	Lecture	2
18-kn-1011-ue	Measuring Technique	Prof. Dr. Mario Kupnik	Practice	1

Module name Electromechanical Systems I					
Module nr. 18-kn-1050	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Teaching content** Structure and design methods of elektromechanical systems, mechanical, acoustical and thermal networks, transducers between mechanical and acoustical networks. Design and devices of electromechanical transducers.
2	**Learning objectives** The module provides the following competencies upon successful completion: Comprehension, description, calculation and application of the most relevant electromechanical transducers, comprising electrostatic transducer (e.g. microphone and accelerometer), piezoelectric transducers (e.g micro motors, micro sensors), electrodynamic transducer (loudspeaker, shaker), piezomagnetic transducer (e.g. ultrasonic source). Design of complex electromechanical systems like sensors and actuators and their applications by applying the discrete element network method.
3	**Recommended prerequisites for participation** Electrical Engineering and Information Technology I
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, M.Sc. MEC, B.Sc. CE, M.Sc. iCE, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Book: Electromechanical Systems in Microtechnic und Mechatronic, Springer 2012, Script for lecture Electromechanical Systems I, Workbook

Courses

Course nr.	Course name		
18-kn-1050-vl	Electromechanical Systems I		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik, M.Sc. Omar Dali, Prof. Dr. techn. Dr.h.c. Andreas Binder		Lecture	2
Course nr.	**Course name**		
18-kn-1050-ue	Electromechanical Systems I		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik, M.Sc. Omar Dali, Prof. Dr. techn. Dr.h.c. Andreas Binder		Practice	2

Module name Electrical Engineering and Information Technology I					
Module nr. 18-kn-1070	**Credit points** 7 CP	**Workload** 210 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Teaching content** Units and Equations: Unit systems, equation writing. Basic definitions: Charge, current, voltage, resistance, energy and power. Currents and voltages in electrical circuits: Ohmic law, node and mesh equations, parallel and series connections, current and voltage measurement, linear and nonlinear elements, superposition method, star-delta-transformation, node and mesh analysis in linear circuits, controlled sources. AC systems: Time-dependent currents and voltages, steady-state mode sinusoidal currents and voltages in linear RLC-circuits, phasor diagrams, resonances in RLC circuits, AC power, locus diagrams, two-port networks, transformer, polyphase systems.
2	**Learning objectives** After successful completion of the module students are able: • to utilize the basic equations in electrical engineering, • to determine the currents and voltages in linear and nonlinear circuits, • to analyze DC and AC systems, • to calculate simple filter and resonant circuits, • to apply the complex calculation in electrical AC systems.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, B.Sc. MedTec, B.Sc. CE, B.Sc. iST, B.Ed. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** • Frohne, H. u.a. Moeller Grundlagen der Elektrotechnik • Clausert, H. u.a. Grundgebiete der Elektrotechnik 1 + 2
Courses	

	Course nr.	**Course name**		
	18-kn-1070-vl	Electrical Engineering and Information Technology I		
	Instructor		**Type**	**SWS**
	Prof. Dr. Mario Kupnik, M.Sc. Felix Herbst		Lecture	3
	Course nr.	**Course name**		
	18-kn-1070-ue	Electrical Engineering and Information Technology I		
	Instructor		**Type**	**SWS**
	Prof. Dr. Mario Kupnik, M.Sc. Felix Herbst, M.Sc. Alexander Altmann		Practice	2

Module name					
Information Theory I: Fundaments					
Module nr. 18-kp-1010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr. techn. Heinz Köppl		

1 Teaching content

This lecture course introduces the fundamentals of information theory, network information theory and coding theory.
Outline:
information, uncertainty, entropy, mutual information, capacity, differential entropy, typical sequences, Gaussian channels, basics of source and channel coding, linear block codes, Shannon's source coding theorem, Shannon's channel coding theorem, capacity of Gaussian channels, capacity of bandlimited channels, Shannon's bound, bandwidth efficiency, capacity of multiple parallel channels and waterfilling, Gaussian vector channel, Multiple Access Channel, Broadcast Channel, rate region.

2 Learning objectives

Upon completion of the module, students will have an understanding of the fundamentals of classic information theory.

3 Recommended prerequisites for participation

Basic knowledge of probability theory

4 Form of examination

Module exam:
- Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

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

7 Usability of the module

B.Sc. etit, M.Sc. CE, B.Sc. CE, M.Sc. iCE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit, M.Sc. etit - CMEE

8 Grade bonus compliant to §25 (2)

9 References

1. T.M. Cover and J.A. Thomas, Elements of Information Theory, Wiley & Sons, 1991.
2. R. W. Yeung, Information Theory and Network Coding, Springer, 2008.
3. Abbas El Gamal and Young-Han Kim, Network Information Theory, Cambrige, 2011.

Courses

Course nr.	Course name		
18-kp-1010-vl	Information Theory I: Fundaments		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Heinz Köppl, M.Sc. Anam Tahir		Lecture	3

	Course nr.	Course name		
	18-kp-1010-ue	Information Theory I: Fundaments		
	Instructor		**Type**	**SWS**
	Prof. Dr. techn. Heinz Köppl, M.Sc. Anam Tahir		Practice	1

Module name					
Bioinformatics I					
Module nr. 18-kp-1020	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr. techn. Heinz Köppl		

1 Teaching content

- Biomolecular foundations of high-throughput measurement techniques (Microarrays, RNA-Seq, genome sequencing, proteinarrays, mass-spectrometry, flow-cytometry, mass-cytometry, genomics, proteomics, metabolomics)
- Foundations of statistics and machine learning (decision theory, regression, classification and clustering)
- Exact substring search, dynamic programming, algorithms for sequence comparison (PAM, BLAST, BLAST2, etc), alignment of multiple sequences (ClustalW, DAlign, etc)
- Important databases in bioinformatics and their use in medicine and biology (GenBank, Gene Expression Omnibus, Rfam, UniProt, Pfam, KEGG, BRENDA, Pathway Commons)
- Analysis of interaction networks (modularity, graph partitioning, spanning trees, differential network analysis, network motifs, STRING database, PathBLAST)
- Introduction to structural biology, structure prediction for RNA and proteins, Protein Data Bank (PDB)

2 Learning objectives

After successful completion students are aware of frequently used high-throughput methods in molecular biology and are familiar with the resulting data format. They know the most important bioinformatics databases and acquired the necessary background to understand standard bioinformatics algorithms and to implement them from scratch in R or Matlab. Students are familiar with the basics of structural analysis and with structure prediction. With respect to communication skills, students learned to exchange informatio, ideas, problems and solutions related to bioinformatics with experts and with lay persons.

3 Recommended prerequisites for participation

„General Computer Science I"

4 Form of examination

Module exam:

- Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)

5 Prerequisite for the award of credit points

Passing of Module final exam

6 Grading

Module exam:

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

7 Usability of the module

B.Sc. MedTec, B.Sc. und M.Sc. iST, B.Sc. WI-etit, M.Sc. etit - CMEE

8 Grade bonus compliant to §25 (2)

9 References

Courses

	Course nr.	Course name		
	18-kp-1020-vl	Bioinformatics I		
	Instructor		**Type**	**SWS**
	Prof. Dr. techn. Heinz Köppl		Lecture	2

Module name Microelectronic Devices					
Module nr. 18-pr-1030	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr. rer. nat. Sascha Preu		

1 Teaching content

1. Introduction: Semiconductor Devices & Microelectronic
2. Semiconductor: Materials, Physics & Technology
3. PN-Junction
4. Metal-Oxide-Semiconductor Capacity
5. Schottky Contact
6. MOS-Field-Effect-Transistor (MOSFET)
7. CMOS: Digital Applications
8. MOS-Memory
9. Bipolar- Junction-Transistor
10. Outlook: Scaling Limits & SET,...

2 Learning objectives

Upon completion of the module, students will have developed an understanding of
- the physical properties and processes in semiconductor devices and materials
- the operation of basic semiconductor devices like diode, MOS-Transistor and bipolar transistor
- the functionality of basic circuits like rectifier circuit and 1-transistor amplifier from the device point of view

Goal: Understand state-of-the art semiconductor devices and circuits as a basis for a successful engineering career

3 Recommended prerequisites for participation

Electrical Engineering and Information Technology I, Electrical Engineering and Information Technology II, Laboratory ETiT, Laboratory Electronics, Mathematics I, Mathematics II, Physics

4 Form of examination

Module exam:
- Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

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

7 Usability of the module

B.Sc. etit, B.Sc. MEC, B.Sc. CE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

Yes

9 References

Skript: Microelectronic devices - the Basics

1. Robert F. Pierret: Semiconductor Device Fundamentals, ISBN 0201543931
2. Roger T. How, Charles G. Sodini: Microelectronics - an Integrated Approach, ISBN 0135885183
3. Richard C. Jaeger: Microelectronic Circuit Design, ISBN 0071143866
4. Y. Taur, T.H. Ning, Fundamentals of Modern VLSI Devices, ISBN 0521559596
5. Thomas Tille, Doris Schmidt-Landsiedel: Mikroelektronik, ISBN 3540204229
6. Michael Reisch: Halbleiter-Bauelemente, ISBN 3540213848

Courses

Course nr.	**Course name**		
18-pr-1030-vl	Microelectronic Devices		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sascha Preu		Lecture	2
Course nr.	**Course name**		
18-pr-1030-ue	Microelectronic Devices		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sascha Preu		Practice	1

Module name Optical Communications - Components					
Module nr. 18-pr-1050	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr. rer. nat. Sascha Preu		

1	**Teaching content** The lecture discusses the working principle of the most important devices and components of modern telecommunication networks and optical data transmission systems. The starting point will be basic physical principles: The nature of light • Wave equation • Polarization • Absorption, transmission, reflection, refraction • Mirrors, HR-/AR coatings Waveguides • Fiber-optic waveguides • Attenuation, modes, dispersion • Fiber types • Connectors and splices • Dispersion and dispersion compensation • Kerr nonlinearity and self-phase modulation Components, e.g.: • Optical filters • Wavelength division multiplexers • Magneto-optical effect / optical isolator / circulator • Electro-optic modulator Lasers • Basics, concepts, types • Erbium-doped fiber lasers / amplifiers (EDFL / EDFA) • Optical semiconductor laser / amplifier (laser diode) Other selected components and devices
2	**Learning objectives** Students understand concepts, basics of physics, design criteria and system requirements (component specifications) of the most important passive and active components of optical communications.
3	**Recommended prerequisites for participation** etit 1 + 2, Physics
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. etit - KTS, M.Sc. iCE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**

9	**References** Lecture slides Textbook (M. Cvijetic, I. B. Djordjevic: „Advanced Optical Communication Systems and Networks“)			
Courses				
	Course nr. 18-pr-1050-vl	**Course name** Optical Communications - Components		
	Instructor Prof. Dr. rer. nat. Sascha Preu		**Type** Lecture	**SWS** 3
	Course nr. 18-pr-1050-ue	**Course name** Optical Communications - Components		
	Instructor Prof. Dr. rer. nat. Sascha Preu		**Type** Practice	**SWS** 1

Module name					
Communication Networks I					
Module nr. 18-sm-1010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. rer. nat. Björn Scheuermann		

1 Teaching 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

This lecture teaches about basic functionalities, services, protocols, algorithms and standards of network communication systems. Competencies acquired 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 prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

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

7	**Usability of the module** B.Sc. etit, B.Sc. MEC, M.Sc. MEC, M.Sc. WI-etit, M.Sc. CE, B.Sc. CE, M.Sc. MedTec, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)** Grade improvement is achieved by solving voluntary additional assignments due weekly in writing during the lecture period. The maximum grade improvement is 1.0. For a grade improvement to be awarded, a minimum number of points (50% of the maximum achievable points) must be reached. Above this minimum number, the grade improvement increases proportionally (from 0.0 grade improvement at the minimum number to a maximum of 1.0 grade improvement at 95% of the maximum achievable points). Above 95% of the maximum achievable points, the bonus is 1.0. Components of the additional assignments can be classical exercises, answering quizzes, creating wiki articles or quizzes. Participation in these is mandatory to receive the grade improvement. The grade improvement has no influence on passing the exam.
9	**References** Selected chapters from the following sources: • Andrew S. Tanenbaum: Computer Networks, 5th Edition, Prentice Hall, 2010 • Andrew S. Tanenbaum: Computernetzwerke, 5. Auflage, Pearson Studium, 2012 • Larry L. Peterson, Bruce S. Davie: Computer Networks: A Systems Approach, 6th Edition, Morgan Kaufmann Publishers, 2021 • Larry L. Peterson, Bruce S. Davie: Computernetze: Eine systemorientierte Einführung, 4. Auflage, Dpunkt Verlag, 2007 • James F. Kurose, Keith W. Ross: Computer Networking: A Top-Down Approach Featuring the Internet, 8th Edition, Pearson, 2021 • James F. Kurose, Keith W. Ross: Computernetzwerke: Der Top-Down-Ansatz, 6. Auflage, Pearson Studium 2014 • R. Srikant, Jean Walrand, Shyam Parekh: Communication Networks: A Concise Introduction, 2nd Edition, Morgan & Claypool, 2017 • Olivier Bonaventure: Computer Networking: Principles, Protocols and Practice, open ebook, https://www.computer-networking.info

Courses

Course nr.	Course name		
18-sm-1010-vl	Communication Networks I		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Björn Scheuermann		Lecture	3
Course nr.	**Course name**		
18-sm-1010-ue	Communication Networks I		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Björn Scheuermann		Practice	1

Module name Logic Design					
Module nr. 18-sm-1040	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. rer. nat. Björn Scheuermann		

1	**Teaching content** Boolean algebra, logic gates, hardware description languages, flipflops, sequential circuits, state-diagrams and -tables, technology mapping, programmable logic circuits
2	**Learning objectives** By this module, Students will be enabled to • rewrite boolean expressions and transform them into circuits of logic gates • analyze and synthesize digital circuits • describe digital circuits in a hardware description language • extract finite state machines from informal descriptions and implement them with synchronous circuits
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, B.Sc. CE, B.Sc. iST, B.Ed. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** David Harris und Sarah Harris: Digital Design and Computer Architecture

Courses

Course nr.	Course name	Instructor	Type	SWS
18-sm-1040-vl	Logic Design	Prof. Dr. rer. nat. Björn Scheuermann	Lecture	3
18-sm-1040-ue	Logic Design	Prof. Dr. rer. nat. Björn Scheuermann, M.Sc. Sebastian Rust	Practice	1

Module name Software Engineering - Introduction					
Module nr. 18-su-1010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1	**Teaching 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 Engineering Body of Knowledge” - get addressed in the indicated depth. Main emphasis is laid upon requirements elicitation techniques (software analysis) and the design of software architectures (software design). Ethical issues are addressed using the “ACM/IEEE-CS Software Engineering Code of Ethics and Professional Practice”. 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 lecture, running examples are utilized to explain and exercise the presented software engineering techniques.
2	**Learning objectives** 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. After successful completion of the module, students should be able to uncover, collect and document essential requirements with respect to a software system in a systematic manner using a model-based 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 prerequisites for participation** sound knowledge of an object-oriented programming language (preferably Java)
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, M.Sc. MEC, B.Sc. MedTec, B.Sc. CE, M.Sc. MedTec, B.Sc. iST, B.Ed. etit, B.Sc. WI-etit, M.Sc. etit - CMEE
8	**Grade bonus compliant to §25 (2)** Grade improvements up to 0.4 per APB 25 (2) due to bonus for regularly submitted homework tasks
9	**References** https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/se-i-v and Moodle

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. Maximilian Kratz		Practice	1

Module name Introduction to Data-Based Modelling					
Module nr. 18-st-1030	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1	**Teaching content** • Data-based modelling (aka machine learning) principles: role of models, different metrics & validation criteria • Standard settings & basic methods (deterministic and probabilistic approaches): Regression (k-NN, linear regression / LASSO, deep neural networks) Classification (trees & forests, logistic regression, deep neural networks) Unsupervised learning (k-means, PCA, mixture models, autoencoder) • Advanced topics: experiment design, dynamic models • Application examples from the electrical engineering domain (energy systems, control & communication tasks) • Outlook to probabilistic graphical models as a unifying framework Practical exercises with Python deepen the understanding and support students' skills to independently solve new problems.
2	**Learning objectives** Students understand the key data-based modelling / machine learning settings and important algorithms for each task. Moreover, the students are able to discover a suitable standard setting of data-based modelling behind many typical applications in the electrical engineering domain. They can then independently apply and adapt standard methods to solve these problems.
3	**Recommended prerequisites for participation** Mathematics I/II/III, Statistics/Probability Theory, Scientific Computing (etit bases courses) Using Python for programming the practical examples should pose no difficulty.
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, M.Sc. etit - DT, M.Sc. etit - EET, B.Sc. CE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)** Grade improvements up to 0.4 according to APB 25(2) through bonus for regularly attended practice/internship appointments and independent work on a case study.
9	**References**

Courses

	Course nr. 18-st-1030-vl	**Course name** Introduction to Data-Based Modelling		
	Instructor Prof. Dr. rer. nat. Florian Steinke, Prof. Dr. techn. Heinz Köppl		**Type** Lecture	**SWS** 2
	Course nr. 18-st-1030-ue	**Course name** Introduction to Data-Based Modelling		
	Instructor Prof. Dr. rer. nat. Florian Steinke, Prof. Dr. techn. Heinz Köppl		**Type** Practice	**SWS** 1
	Course nr. 18-st-1030-pr	**Course name** Introduction to Data-Based Modelling		
	Instructor Prof. Dr. rer. nat. Florian Steinke, Prof. Dr. techn. Heinz Köppl		**Type** Lab	**SWS** 1

Module name Fundamentals of Signal Processing					
Module nr. 18-zo-1030	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir		

1	**Teaching content** The course covers the following topics: • The basic concepts of stochastic • The sampling theorem • Discrete-time noise processes and their properties • Description of noise processes in the frequency domain • Linear time-invariant systems: FIR and IIR filters • Filtering of noise processes: AR, MA, and ARMA models • The Matched filter • The Wiener filter • Properties of estimators • The method of least squares
2	**Learning objectives** After successful completion of the module, students understand the basics of probability theory so that they can apply them to stochastic signals in the course of the lecture. In particular, students will be able to describe stochastic processes in the time and frequency domains and analyze their interaction with linear time-invariant systems. Students know the basic properties of estimators. They are able to design optimal filters and apply the method of least squares to problems.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS) The examination is a written exam (duration: 120 minutes). If less than 11 students are registered for the course, the examination will be an oral one (duration: 30 min.). The type of examination will be announced at the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, B.Sc. MedTec, B.Sc. CE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

	Lecture notes and slides can be downloaded here: • http://www.spg.tu-darmstadt.de • Moodle platform Further reading: • A. Papoulis: Probability, Random Variables and Stochastic Processes. McGraw-Hill, Inc., third edition, 1991. • P. Z. Peebles, Jr.: Probability, Random Variables and Random Signal Principles. McGraw-Hill, Inc., fourth edition, 2001. • E. Hänsler: Statistische Signale; Grundlagen und Anwendungen. Springer Verlag, 3. Auflage, 2001. • J. F. Böhme: Stochastische Signale. Teubner Studienbücher, 1998. • A. Oppenheim, W. Schafer: Discrete-time Signal Processing. Prentice Hall Upper Saddle River,1999.

Courses

Course nr.	Course name		
18-zo-1030-vl	Fundamentals of Signal Processing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Abdelhak Zoubir		Lecture	3
Course nr.	**Course name**		
18-zo-1030-ue	Fundamentals of Signal Processing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Abdelhak Zoubir		Practice	1

1.2 Labs

Module name Actuators for Mechatronic Systems Laboratory					
Module nr. 18-bt-1030	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Yves Burkhardt		

1	**Teaching content** Safety instructions; Practical experiments about electrical drive systems and mechatronic actuators: • Report preparation (one for each group) for each experiment • Individual review of the students' knowledge (individual performance) during and/or at the end of the semester • The grading consists of the evaluation of the group performance and the individual performance.
2	**Learning objectives** On completion of the module students will have trained the use of mechanical actors and acquired knowledge in using the actors and measuring them.
3	**Recommended prerequisites for participation** Lecture "Elektrische Maschinen und Antriebe" and "Maschinenelemente und Mechatronik 1"
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) The examination has the form of a Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. MEC, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Detailed textbook with description for the performance of the lab tests

Courses

Course nr.	Course name	Instructor	Type	SWS
18-bt-1030-pr	Actuators for Mechatronic Systems Laboratory	Prof. Dr.-Ing. Yves Burkhardt	Lab	3
18-bt-2090-tt	Laboratory Briefing	Dr.-Ing. Björn Deusinger, Prof. Dr.-Ing. Yves Burkhardt	Tutorial	0

Module name
Mechatronics Workshop

Module nr.	Credit points	Workload	Self-study	Module duration	Module cycle
18-bt-1050	2 CP	60 h	45 h	1 Term	Every Semester

Language	Module owner
German	Prof. Dr.-Ing. Yves Burkhardt

1 Teaching content

Im Mechatronik-Workshop fertigen die Studierenden selbstständig eine Kugelbahn mit elektrischer Beförderungsanlage. Hierzu gilt es die Maßpläne zu erfassen und die erforderlichen Komponenten (u.a. Leiterplatine, Bahnwege und -halterungen) sowohl im Elektroniklabor als auch in der Werkstatt zu fertigen. Der Workshop ermöglicht den Studierenden somit wichtige Einblicke in die Konstruktion und die Modellarbeit.

2 Learning objectives

After completing the module students have an understanding of construction plans, circuit layout design, practical experience with turning, drilling and milling machines.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B.Sc. etit, B.Sc. MEC, M.Sc. MEC, M.Sc. etit - EET, M.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

9 References

- Lecture Notes „Mechatronics Workshop“
- J. Dillinger et al.: Fachkunde Metall, Europa-Lehrmittel, 2007
- U. Tietze, C. Schenk, E. Gamm: Halbleiter-Schaltungstechnik, Springer, 2012

Courses

Course nr.	Course name		
18-bt-1050-pr	Mechatronics Workshop		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Yves Burkhardt		Lab	1

Module name					
Laboratory Control Engineering I					
Module nr. 18-fi-1020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Rolf Findeisen		

1	**Teaching content** Using appropriate test benches the students apply controller design methods taught in the basic lecture of control systems. The priority hereby lies in the application of the design methods and the evaluation of the parameters they provide. Additionally, some further topics of the domain of control systems (e.g. automation engineering, data-driven modelling) are presented by practical Experiments.
2	**Learning objectives** After completion of this module the students will be able to practically apply the modelling and design techniques for different dynamic systems presented in the module "System dynamics and control systems I" to real lab experiments and to bring them into operation at the lap setup.
3	**Recommended prerequisites for participation** System Dynamics and Control Systems I
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, p/np RS) Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, M.Sc. etit - EET, M.Sc. WI-etit, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Lab handouts will be given to students.

Courses

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

Module name Laboratory Matlab/Simulink I					
Module nr. 18-fi-1030	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 45 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr.-Ing. Rolf Findeisen		

1	**Teaching 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** Fundamentals in the handling of Matlab/Simulink and the application to control engineering tasks.
3	**Recommended prerequisites for participation** The lab should be attended in parallel or after the lecture "System Dynamics and Control Systems I"
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, M.Sc. etit - EET, B.Sc. MedTec, M.Sc. MedTec, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)** In case of E-Learning: Possibility to improve the grade up to 1,0
9	**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.	Course name		
18-fi-1030-pr	Laboratory Matlab/Simulink I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Findeisen, M.Sc. Alexander Steinke, M.Sc. Sebastian Hirt		Lab	3

Module name Digital Design Lab					
Module nr. 18-hb-1030	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Christian Hochberger		

1	**Teaching content** • Introduction to the MP3 encoding standard for audio signals • Analysis of the individual steps of the decoding process wrt. the used algo-rithms • Analysis of the individual steps of the decoding process wrt. the storage of in-termediate results • Design and configuration of the datapath to realize the individual process steps • Simulation on functional level and with timing annotation • Check, whether the design meets all restrictions • Test of the final HW design with all relevant MP3 variants (short and long frames)
2	**Learning objectives** After successfully completing the module, students will be able to map complex processes onto a digital target architecture by hand. They master the tools for implementing their solution on an FPGA. They know strategies to systematically search for errors. They can explore a design through simulation.
3	**Recommended prerequisites for participation** Basic knowledge of digital design
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral examination, Duration: 15 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
18-hb-1030-pr	Digital Design Lab		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Lab	2

Module name Electronics Lab					
Module nr. 18-ho-1031	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Teaching content** Students conduct lab experiments on: • Electronic components: diodes, transistors, integrated circuits • Analog circuits: operational amplifiers, active and passive filters, modelling and simulation with SPICE, discrete transistor amplifiers and output stages • Digital circuits: discrete digital logic, state machines, HDL programming, EDA tools for FPGAs
2	**Learning objectives** After completing the module successfully 1. students are able to conduct measurements on analog and digital circuits in a lab setting 2. comprehend how a complex electronic system is assembled from basic circuit blocks 3. to design a state machine and implement in a hardware description language on an FPGA
3	**Recommended prerequisites for participation** Basics of Electrical Engineering; Lecture "Electronics" which is running in parallel
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, p/np RS) Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, B.Sc. iST, B.Ed. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Slide Copies of Lecture "Electronics"; Paul Horowitz and Winfried Hill, "The Art of Electronics"

Courses

Course nr.	**Course name**		
18-ho-1031-pr	Electronics Lab		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Lecture	2

	Course nr.	Course name		
	18-ho-1030-ev	Electronics Lab - Introductory Meeting		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Klaus Hofmann		Introductory course	0

<table>
<tr><td colspan="6">Module name
HDL Lab</td></tr>
<tr><td>Module nr.
18-ho-1090</td><td>Credit points
6 CP</td><td>Workload
180 h</td><td>Self-study
135 h</td><td>Module duration
1 Term</td><td>Module cycle
Summer term</td></tr>
<tr><td colspan="3">Language
English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Klaus Hofmann</td></tr>
</table>

<table>
<tr><td>1</td><td>Teaching content
Realisation of a VHDL- or Verilog-based VLSI System Design Project in a Team with industrial constraints</td></tr>
<tr><td>2</td><td>Learning objectives
A student is, after successful completion of this module, able to

1. design, optimize and verify a complex digital system (e.g. a pipelined CPU or signal processor) using Verilog or VHDL,
2. synthesize the HDL description using commercial CAD software to a gate level description
After successful completion of this module the students are able to work constructively on a feasible solution. Aside, they are able to mutually support each other and present intermediate results to peers, and achieve an overall feasible solution.</td></tr>
<tr><td>3</td><td>Recommended prerequisites for participation
Lecture Computer Aided Design for System on Chips,
At least one high-level Programming Language, Basic Know-How Linux/Unix, Computer Architectures</td></tr>
<tr><td>4</td><td>Form of examination
Module exam:
• Module exam (Study achievement, Oral/written examination, Default RS)
Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.</td></tr>
<tr><td>5</td><td>Prerequisite for the award of credit points
Passing the final module examination</td></tr>
<tr><td>6</td><td>Grading
Module exam:
• Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td>Usability of the module
B.Sc. MEC, M.Sc. etit - DT, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. iCE, B.Sc. und M.Sc. iST</td></tr>
<tr><td>8</td><td>Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td>References
Lecture slides „CAD4SoC"</td></tr>
</table>

<table>
<tr><td colspan="4">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-ho-1090-pr</td><td colspan="2">Course name
HDL Lab</td></tr>
<tr><td>Instructor
Prof. Dr.-Ing. Klaus Hofmann</td><td>Type
Lab</td><td>SWS
3</td></tr>
</table>

Module name					
Measurement Technology Lab					
Module nr. 18-kn-1031	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Teaching content** • Measuring signals in the time domain using digital storage oscilloscopes, trigger constraints • Measuring signals in the frequency domain using digital storage oscilloscopes, measuring errors (aliasing/under sampling, leackage) and window functions • Measuring mechanical quantities with appropriate sensors, sensor electronics/amplifier circuits • Computer-based measurements and ultrasound sensors • Read and process sensor signals and control an automated process using a programmable logic controller (PLC) • First experiments with robotic and medical robots for insertion of needles
2	**Learning objectives** After having successfully completed the course participants are familiar with the use of measuring devices, sensors and electronics. They know about restrictions and possible measuring errors. Also, participants enhance their knowledge of time- and frequency-domain and the connections between both by the oscilloscope measurements. Regarding methodical skills participants are able to record measurement results during laboratory work and to interpret the measured data afterwards.
3	**Recommended prerequisites for participation** Electrical Engineering and Information Technology I and II
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, p/np RS) The examination has the form of a Report (including submission of programming code) and/or a Presentation and/or an Oral examination and/or a Colloquium (testate). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, B.Sc. MedTec, B.Sc. CE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** • Script of the practical course • Lerch, Reinhard: Elektrische Messtechnik : Analoge, digitale und computergestützte Verfahren. 5. neu bearbeitete Auflage. Berlin: Springer, 2010. - ISBN 978-3642054549
Courses	

	Course nr. 18-kn-1031-pr	Course name Measuring Technique Lab		
	Instructor Prof. Dr. Mario Kupnik		**Type** Lab	**SWS** 2

Module name					
Electrical Engineering and Information Technology Lab I					
Module nr. 18-kn-1041	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 60 h	**Module duration** 2 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Teaching content** After a safety instruction for electrical equipment, students dolab experiments covering foundations of electrical engineering by using theoretical and experimental instructions to improve basic electrical understanding. Building up a test set autonomously and performing of measurements and evaluations in the form of logs to confirm the theoretical knowledge and lead to independent work in practice. The following experiments are performed: • Investigate real behavior of ohmic resistors • Investigate real behavior of capacitors and inductors • Calculate impedances of basic two-terminal circuits using network theory • Measure of electrical power in AC circuits and investigate in the real behaviour of transformers
2	**Learning objectives** Upon successful completion of the module, students will be able to: 1. perform the measurement of basic electrical parameters of DC and AC circuits, independently and in compliance with safety rules 2. measuring the frequency response of passive electrical networks and resonant circuits, and electric power measurement 3. the measurement of circuits for the determination of magnetic, electro-thermal and high-frequency. You have to be able to build and run your own measurements 4. interpretations of the measurement results in terms of its technical meaning, but also their accuracy and error sources safely 5. work together in internship groups 6. To prepare measurement protocols in detail
3	**Recommended prerequisites for participation** Parallel attending the lectures and exercises, "Electrical Engineering I and II"
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, p/np RS) Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, B.Sc. MedTec, B.Sc. iST, B.Ed. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**

9	**References** Detailed script with instructions for the experiments; Clausert, H. / Wiesemann, G.: Grundgebiete der Elektrotechnik, Oldenbourg,1999

Courses

Course nr.	**Course name**		
18-kn-1040-pr	Electrical Engineering and Information Technology Lab I A		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik		Lab	2
Course nr.	**Course name**		
18-kn-1041-pr	Electrical Engineering and Information Technology Lab I B		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik		Lab	2
Course nr.	**Course name**		
18-kn-1040-tt	Electrical Engineering and Information Technology I, Safety instructions and rules		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik		Tutorial	0

<table>
<tr><td colspan="6">Module name
Laboratory of Biomedical Engineering</td></tr>
<tr><td>Module nr.
18-kp-1050</td><td>Credit points
2 CP</td><td>Workload
60 h</td><td>Self-study
30 h</td><td>Module duration
1 Term</td><td>Module cycle
Winter term</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr. techn. Heinz Köppl</td></tr>
</table>

<table>
<tr><td>1</td><td>Teaching content
This module addresses the different branches of biomedical engineering. Contents of lab experiments cover current topics of biomedical engineering like medical robotics, measuring and sensor technology, biomechanics, radiotherapy, imaging techniques, biosignal-monitoring, gerontology or Lab-on-a-Chip.</td></tr>
<tr><td>2</td><td>Learning objectives
After successful completion of this module students will be familiar with practical applications of medical engineering and have learnt to identify necessary practical methods and work techniques and to implement them correctly. They will also have gained experience in experimental works in autonomous small groups from a medical engineering context.</td></tr>
<tr><td>3</td><td>Recommended prerequisites for participation
„Electrical Engineering and Information Technology I“, and „Electrical Engineering and Information Technology II“</td></tr>
<tr><td>4</td><td>Form of examination
Module exam:
Module exam (Study achievement, Oral/written examination, p/np RS)
Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.</td></tr>
<tr><td>5</td><td>Prerequisite for the award of credit points
Passing of Module final exam</td></tr>
<tr><td>6</td><td>Grading
Module exam:
Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td>Usability of the module
B.Sc. MedTec</td></tr>
<tr><td>8</td><td>Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td>References</td></tr>
</table>

<table>
<tr><td colspan="4">Courses</td></tr>
<tr><td>Course nr.
18-kp-1050-pr</td><td colspan="3">Course name
Laboratory of Biomedical Engineering</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Jürgen Adamy, Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr.-Ing. Abdelhak Zoubir, Prof. Dr. techn. Heinz Köppl, M.Sc. Mengguang Li, Prof. Ph.D. Thomas Burg</td><td>Type
Lab</td><td>SWS
2</td></tr>
</table>

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-kp-1050-tt</td><td colspan="3">Course name
Preliminary</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. techn. Heinz Köppl</td><td>Type
Preliminary discussion</td><td>SWS
0</td></tr>
</table>

Module name Software Lab Finite Integration Technique					
Module nr. 18-sc-1010	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 165 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. rer. nat. Sebastian Schöps		

1	**Teaching content** Various topics are: 1. Introduction 2. Basics of FIT I 3. Basics of FIT II 4. Static problems (electrical/magnetical) (scalar potential) 5. Magnetostatic problems, frequency domain 6. Time domain integration techniques: Leapfrog I 7. Time domain integration techniques: Leapfrog II 8. Other physical problems: heat conduction 9. Other discretization methods: Finite Element Method.
2	**Learning objectives** Students will understand basic concepts of numerical solution techniques to field problems related to different physical domains. They will exhibit the ability to write small simulation programs.
3	**Recommended prerequisites for participation** Finite Integration Technique (18-dg-1030), also parallel participation possible.
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. CE
8	**Grade bonus compliant to §25 (2)**
9	**References** Course notes will be provided via Moodle.

Courses

Course nr.	**Course name**		
18-sc-1010-pr	Software Lab Finite Integration Technique		
Instructor Prof. Dr. rer. nat. Sebastian Schöps		**Type** Lab	**SWS** 5

Module name					
Software Lab Scientific Computing					
Module nr. 18-sc-1030	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. rer. nat. Sebastian Schöps		

1	**Teaching content** Numerical algorithms: numerical solution of linear systems of equations, interpolation, numerical quadrature methods, nonlinear systems of equations, initial value problem for ordinary differential equations, eigenvalue/eigenvector computation.
2	**Learning objectives** After completion of the module, fundamental algorithms of numerics are understood and can be prototypically implemented and automatically tested in software by the students.
3	**Recommended prerequisites for participation** Mathematics 1, Mathematics 2, Mathematics 3 (in parallel)
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, p/np RS) Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, B.Sc. iST, B.Ed. etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
18-sc-1030-pr	Software lab scientific computing		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sebastian Schöps		Lab	2

Module name					
Multimedia Communications Lab I					
Module nr. 18-sm-1020	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 45 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Ralf Steinmetz		

1 Teaching content

The course deals with cutting-edge development topics in the area of multimedia communication systems. Besides 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 competencies 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
- Adaptive educational technologies
- Natural language processing in education

The concrete list of topics can be found each semester on the corresponding teaching website of KOM.

2 Learning objectives

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 prerequisites 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 exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

	Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, M.Sc. MEC, M.Sc. MedTec, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**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. rer. nat. Björn Scheuermann, Dr. Ing. Julian Zobel, M.Sc. Fridolin Siegmund, Prof. Dr.-Ing. Ralf Steinmetz		Lab	3

Module name Software Lab					
Module nr. 18-st-1022	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1	**Teaching content** The lab course covers the following basic software development skills: • Knowledge of the programing language Java (syntax, underlying concepts, conventions) • Use of a development environment (Eclipse) • Software documentation using JavaDoc • Systematic testing with JUnit • Software development in teams (incl. use of git) • Introduction to data structures and algorithms, first complexity analyses These topics are developed in conjunction with a game that models the renewable electricity supply of islands. Students participating in the lab deepen their basic programming knowledge (acquired in Computer Science for Engineers). The focus is on development of "medium-size" software in contrast to programming small toy examples, working in teams, and the development in conjunction with an existing software framework.
2	**Learning objectives** Upon completion of the module, students have acquired the ability to collaborate in a team and to systematically develop a given software system (framework). They have the skills to implement, test and document smaller software systems and have an understanding of the need to use comprehensive software engineering techniques for the development of large software systems.
3	**Recommended prerequisites for participation** Basics in Java (as taught in Introduction to Computer Science for Engineers).
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, p/np RS) Report (including submission of programming code) and/or a Presentation and/or an Oral examination (25 minutes) and/or a Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, M.Sc. MEC, B.Ed. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** http://www.eins.tu-darmstadt.de/teaching/courses/software-praktikum

Courses

Course nr.	Course name		
18-st-1020-pr	Software Lab		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Florian Steinke, M.Sc. Kirill Kuroptev, M.Sc. Julia Barbosa		Lab	3

Module name C/C++ Programming Lab					
Module nr. 18-fi-1040	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1 Teaching content

The programming lab is divided into two parts.
In the first part of the lab, the basic concepts of the programming languages C and C++ are taught during the semester through practical exercises and presentations. All aspects will be deepened by extended practical exercises in self-study on the computer. For this purpose, all necessary materials such as presentation slides, presentation recordings, exercises, sample solutions of the exercises and recordings of the exercise discussions are provided in purely digital form.
The second part of the lab is about programming a microcontroller using the C programming language. For this purpose, the students are provided with a microcontroller for two days, with which they can work on practical programming tasks under supervision.
The following topics will be covered in the course:

- Basic concepts of the programming languages C and C++
- Memory management and data structures
- Object oriented programming in C++
- (Multiple) Inheritance, polymorphism, parametric polymorphism
- (Low-level) Programming of embedded systems with C

2 Learning objectives

During the module, students acquire basic knowledge of C and C++ language constructs. Additionally, they learn how to handle both the procedural and the object-oriented programming style. Through practical programming exercises, students acquire a feeling for common mistakes and dangers in dealing with the language, especially in the development of embedded system software, and learn suitable solutions to avoid them. Furthermore, through hands-on experience with embedded systems, students acquire additional expertise in low-level programming.

3 Recommended prerequisites for participation

Java skills

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

The examination has the form of a Report (including submission of programming code) and/or a Presentation and/or an Oral examination (25 minutes) and/or a Colloquium (testate), but never more than two out of it. From a number of 10 students registered for the course, the examination may take place in form of a written exam (duration: 90 minutes). The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B.Sc. etit, B.Sc. MEC, M.Sc. MEC, B.Sc. MedTec, M.Sc. MedTec, B.Sc. und M.Sc. iST, B.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

	Grade improvements up to 1.0 according to APB 25(2) can be achieved through a bonus system for regularly submitted bonus assignments. The content of the course is divided into 5 topics. For each topic (Fundamentals, Memory Management, Object Oriented Programming, Advanced Concepts, and C) there is one assignment sheet with one bonus assignment each, which must be solved and handed in by the students. The assignment is considered either pass or fail. Bonus credit is given in proportion to the ratio of passed bonus tasks and the total number of bonus tasks. Total bonus = 1.0 × Number of passed tasks / Total number of bonus tasks
9	**References** A recording of the presentations as well as presentation slides are available in the corresponding Moodle course. Additional literature: • Schellong, Helmut: Moderne C Programmierung, 3. Auflage. Springer, 2014 • Schneeweiß, Ralf: Moderne C++ Programmierung, 2. Auflage. Springer, 2012 • Stroustrup, Bjarne: Programming - Principles and Practice Using C++, 2nd edition. Addison-Wesley, 2014 • Stroustrup, Bjarne: A Tour of C++, 2nd edition. Pearson Education, 2018

Courses

Course nr.	Course name		
18-fi-1040-pr	C/C++ Programming Lab		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Findeisen, Prof. Dr. rer. nat. Andreas Schürr		Lab	2

1.3 Seminars

Module name Seminar Electronic Circuits					
Module nr. 18-ho-1070	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Teaching content** Analysis of state-of-the-art circuit concepts and presentation of selected examples
2	**Learning objectives** After attending the seminar, a student is capable of analysing of state-of-the-art circuit concepts and preparing didactical materials and presentations, based on the know-how gained in the lectures "Electronics" and "Analog Integrated Circuit Design"
3	**Recommended prerequisites for participation** Electronics, Electronic and Integrated Circuits
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be provided at the begin of the seminar

Courses

Course nr.	Course name		
18-ho-1070-se	Seminar Electronic Circuits		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Seminar	**SWS** 2

1.4 Modules Scientific working and writing

Module name					
Scientific Working and Writing					
Module nr. 18-ad-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, B.Sc. MedTec, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
18-ad-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jürgen Adamy		Introductory seminar course	2

Module name					
Scientific Working and Writing					
Module nr. 18-bf-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Oliver Boine-Frankenheim		

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
18-bf-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr. Oliver Boine-Frankenheim		Introductory seminar course	2

<table>
<tr><td colspan="6">Module name
Scientific Working and Writing</td></tr>
<tr><td>Module nr.
18-bt-1001</td><td>Credit points
3 CP</td><td>Workload
90 h</td><td>Self-study
60 h</td><td>Module duration
1 Term</td><td>Module cycle
Every Semester</td></tr>
<tr><td colspan="3">Language
German/English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Yves Burkhardt</td></tr>
</table>

<table>
<tr><td>1</td><td>Teaching content
Content and goals
• Elaboration of a technical topic in cooperation with a research associate as supervisor
• Detailed study of technical articles
• Deeper understanding of the technical topic treated therein
• Practical experience with technical documentation
• Learning modern presentation techniques and their application
• Presentation and discussion of the technical topic in front of a group of people</td></tr>
<tr><td>2</td><td>Learning objectives
The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.</td></tr>
<tr><td>3</td><td>Recommended prerequisites for participation</td></tr>
<tr><td>4</td><td>Form of examination
Module exam:
• Module exam (Study achievement, Oral/written examination, Default RS)
Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.</td></tr>
<tr><td>5</td><td>Prerequisite for the award of credit points
Passing the final module examination</td></tr>
<tr><td>6</td><td>Grading
Module exam:
• Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td>Usability of the module
B.Sc. etit, B.Ed. etit, B.Sc. WI-etit</td></tr>
<tr><td>8</td><td>Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td>References</td></tr>
</table>

<table>
<tr><td colspan="4">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-bt-1001-ps</td><td colspan="2">Course name
Scientific working and writing</td></tr>
<tr><td>Instructor
Prof. Dr.-Ing. Yves Burkhardt</td><td>Type
Introductory seminar course</td><td>SWS
2</td></tr>
</table>

Module name Scientific Working and Writing					
Module nr. 18-bu-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Ph.D. Thomas Burg		

1 Teaching content

Content and goals

- Elaboration of a technical topic in cooperation with a research associate as supervisor
- Detailed study of technical articles
- Deeper understanding of the technical topic treated therein
- Practical experience with technical documentation
- Learning modern presentation techniques and their application
- Presentation and discussion of the technical topic in front of a group of people

2 Learning objectives

The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B.Sc. etit, B.Sc. MedTec, B.Ed. etit, B.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

9 References

Courses

Course nr.	Course name		
18-bu-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Ph.D. Thomas Burg		Introductory seminar course	2

<table>
<tr><td colspan="6">Module name
Scientific Working and Writing</td></tr>
<tr><td>Module nr.
18-dg-1001</td><td>Credit points
3 CP</td><td>Workload
90 h</td><td>Self-study
60 h</td><td>Module duration
1 Term</td><td>Module cycle
Every Semester</td></tr>
<tr><td colspan="3">Language
German/English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Herbert De Gersem</td></tr>
</table>

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
18-dg-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Herbert De Gersem		Introductory seminar course	2

Module name Scientific Working and Writing					
Module nr. 18-fi-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Rolf Findeisen		

1 Teaching content

Content and goals

- Elaboration of a technical topic in cooperation with a research associate as supervisor
- Detailed study of technical articles
- Deeper understanding of the technical topic treated therein
- Practical experience with technical documentation
- Learning modern presentation techniques and their application
- Presentation and discussion of the technical topic in front of a group of people

2 Learning objectives

The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B.Sc. etit, B.Sc. MedTec, B.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

9 References

Courses

Course nr.	**Course name**		
18-fi-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Findeisen		Introductory seminar course	2

Module name Scientific Working and Writing					
Module nr. 18-fr-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr. habil. Torsten Frosch		

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** Current scientific literature is recommended separately for the individual experiments. The following books can serve as a general reference: • Bahaa E. A. Saleh und Malvin Carl Teich, Optik und Photonik, Wiley • Eugen Hecht, Optik, Oldenburg Verlag • Frank L. Pedrotti, Leno S. Pedrotti, Werner Bausch, Hartmut Schmidt, Optik für Ingenieure, Springer • Herman Haken, Hans Christoph Wolf, Atom- und Quantenphysik, Springer • Herman Haken, Hans Christoph Wolf, Molekülphysik und Quantenchemie, Springer • Peter W. Atkins, Julio de Paula, Michael Bär, Physikalische Chemie, Wiley • Wolfgang Demtröder, Laserspektroskopie 1&2, Springer
Courses	

<table>
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18-fr-1001-ps</td><td colspan="3">Course name
Scientific working and writing</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. habil. Torsten Frosch</td><td>Type
Introductory seminar course</td><td>SWS
2</td></tr>
</table>

Module name Scientific Working and Writing					
Module nr. 18-gr-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Christian Graeff		

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
18-gr-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Graeff		Introductory seminar course	2

Module name Scientific Working and Writing					
Module nr. 18-gt-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MedTec, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
18-gt-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Gerd Griepentrog		Introductory seminar course	2

<table>
<tr><td colspan="6">Module name
Scientific Working and Writing</td></tr>
<tr><td>Module nr.
18-ha-1001</td><td>Credit points
3 CP</td><td>Workload
90 h</td><td>Self-study
60 h</td><td>Module duration
1 Term</td><td>Module cycle
Every Semester</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr.-Ing. Christoph Hoog Antink</td></tr>
</table>

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** To be determined individually depending on the topic.

Courses

Course nr.	Course name		
18-ha-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christoph Hoog Antink		Introductory seminar course	2

Module name Scientific Working and Writing					
Module nr. 18-hb-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr.-Ing. Christian Hochberger		

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
18-hb-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Introductory seminar course	2

Module name Scientific Working and Writing					
Module nr. 18-ho-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation** Lecture "Elektronische und Integrierte Schaltungen"
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
18-ho-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Introductory seminar course	2

Module name Scientific Working and Writing					
Module nr. 18-hs-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MedTec, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Literature will be provided based on the topic.

Courses

Course nr.	Course name		
18-hs-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jutta Hanson		Introductory seminar course	2

<table>
<tr><td colspan="6">Module name
Scientific Working and Writing</td></tr>
<tr><td>Module nr.
18-ja-1001</td><td>Credit points
3 CP</td><td>Workload
90 h</td><td>Self-study
60 h</td><td>Module duration
1 Term</td><td>Module cycle
Every Semester</td></tr>
<tr><td colspan="3">Language
German/English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Vahid Kooshkghazi</td></tr>
</table>

1 Teaching content

Content and goals

- Elaboration of a technical topic in cooperation with a research associate as supervisor
- Detailed study of technical articles
- Deeper understanding of the technical topic treated therein
- Practical experience with technical documentation
- Learning modern presentation techniques and their application
- Presentation and discussion of the technical topic in front of a group of people

2 Learning objectives

The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B.Sc. etit

8 Grade bonus compliant to §25 (2)

9 References

Courses

<table>
<tr><td>Course nr.
18-ja-1001-ps</td><td colspan="2">Course name
Scientific working and writing</td></tr>
<tr><td>Instructor
Prof. Dr.-Ing. Vahid Kooshkghazi</td><td>Type
Introductory seminar course</td><td>SWS
2</td></tr>
</table>

Module name Scientific Working and Writing					
Module nr. 18-jk-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation** Fundamental knowledge in microwave engineering, e.g. lecture "Hochfrequenztechnik 1".
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MedTec, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** According to the advices and recommendations of the project supervisor

Courses

Course nr.	**Course name**		
18-jk-1001-ps	Scientific working and writing		
Instructor Prof. Dr.-Ing. Rolf Jakoby, Dr.-Ing. Martin Schüßler		**Type** Introductory seminar course	**SWS** 2

Module name Scientific Working and Writing					
Module nr. 18-kb-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Harald Klingbeil		

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents
3	**Recommended prerequisites for participation** Good understanding of electromagnetic fields, broad knowledge of various electrical engineering disciplines
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** Suitable material is provided based on specific topic

Courses

Course nr.	**Course name**		
18-kb-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Harald Klingbeil		Introductory seminar course	2

Module name					
Scientific Working and Writing					
Module nr. 18-kc-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr. Myriam Koch		

1 Teaching content

Content and goals

- Elaboration of a technical topic in cooperation with a research associate as supervisor
- Detailed study of technical articles
- Deeper understanding of the technical topic treated therein
- Practical experience with technical documentation
- Learning modern presentation techniques and their application
- Presentation and discussion of the technical topic in front of a group of people

2 Learning objectives

The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B.Sc. etit, B.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

9 References

Courses

Course nr.	Course name		
18-kc-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr. Myriam Koch, M.Sc. Manuel Philipp		Introductory seminar course	2

Module name Scientific Working and Writing					
Module nr. 18-kh-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Tran Quoc Khanh		

1 Teaching content

Content and goals

- Elaboration of a technical topic in cooperation with a research associate as supervisor
- Detailed study of technical articles
- Deeper understanding of the technical topic treated therein
- Practical experience with technical documentation
- Learning modern presentation techniques and their application
- Presentation and discussion of the technical topic in front of a group of people

2 Learning objectives

The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B.Sc. etit, B.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

9 References

Courses

Course nr.	**Course name**		
18-kh-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Tran Quoc Khanh		Introductory seminar course	2

Module name
Scientific Working and Writing

Module nr.	Credit points	Workload	Self-study	Module duration	Module cycle
18-kl-1001	3 CP	90 h	60 h	1 Term	Every Semester

Language	Module owner
German/English	Prof. Dr.-Ing. Anja Klein

1 Teaching content

Content and goals

- Elaboration of a technical topic in cooperation with a research associate as supervisor
- Detailed study of technical articles
- Deeper understanding of the technical topic treated therein
- Practical experience with technical documentation
- Learning modern presentation techniques and their application
- Presentation and discussion of the technical topic in front of a group of people

2 Learning objectives

The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B.Sc. etit, B.Sc. MedTec, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

9 References

Literature will be announced during the course.

Courses

Course nr.	Course name
18-kl-1001-ps	Scientific working and writing

Instructor	Type	SWS
Prof. Dr.-Ing. Anja Klein	Introductory seminar course	2

Module name Scientific Working and Writing					
Module nr. 18-kn-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MedTec, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
18-kn-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr. Mario Kupnik		Introductory seminar course	2

Module name Scientific Working and Writing					
Module nr. 18-kp-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language English			**Module owner** Prof. Dr. techn. Heinz Köppl		

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MedTec, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
18-kp-1001-ps	Scientific working and writing		
Instructor Prof. Dr. techn. Heinz Köppl		**Type** Introductory seminar course	**SWS** 2

<table>
<tr><td colspan="7">Module name
Scientific Working and Writing</td></tr>
<tr><td colspan="2">Module nr.
18-me-1001</td><td>Credit points
3 CP</td><td>Workload
90 h</td><td>Self-study
60 h</td><td>Module duration
1 Term</td><td>Module cycle
Every Semester</td></tr>
<tr><td colspan="4">Language
English</td><td colspan="3">Module owner
Prof. Dr. rer. nat. Markus Meinert</td></tr>
<tr><td>1</td><td colspan="6">Teaching content
Content and goals
• Elaboration of a technical topic in cooperation with a research associate as supervisor
• Detailed study of technical articles
• Deeper understanding of the technical topic treated therein
• Practical experience with technical documentation
• Learning modern presentation techniques and their application
• Presentation and discussion of the technical topic in front of a group of people</td></tr>
<tr><td>2</td><td colspan="6">Learning objectives
The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents</td></tr>
<tr><td>3</td><td colspan="6">Recommended prerequisites for participation</td></tr>
<tr><td>4</td><td colspan="6">Form of examination
Module exam:
• Module exam (Study achievement, Oral/written examination, Default RS)
Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.</td></tr>
<tr><td>5</td><td colspan="6">Prerequisite for the award of credit points
Passing the final module examination</td></tr>
<tr><td>6</td><td colspan="6">Grading
Module exam:
• Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td colspan="6">Usability of the module
B.Sc. etit</td></tr>
<tr><td>8</td><td colspan="6">Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td colspan="6">References
Lecture notes: Introduction to Spintronics (Prof. Markus Meinert)</td></tr>
<tr><td colspan="7">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-me-1001-ps</td><td colspan="5">Course name
Scientific working and writing</td></tr>
<tr><td colspan="4">Instructor
Prof. Dr. rer. nat. Markus Meinert</td><td>Type
Introductory seminar course</td><td>SWS
2</td></tr>
</table>

Module name Scientific Working and Writing					
Module nr. 18-mu-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Michael Muma		

1 Teaching content

Content and goals

- Elaboration of a technical topic in cooperation with a research associate as supervisor
- Detailed study of technical articles
- Deeper understanding of the technical topic treated therein
- Practical experience with technical documentation
- Learning modern presentation techniques and their application
- Presentation and discussion of the technical topic in front of a group of people

2 Learning objectives

The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B.Sc. etit

8 Grade bonus compliant to §25 (2)

9 References

Courses

Course nr.	**Course name**		
18-mu-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Michael Muma		Introductory seminar course	2

Module name Scientific Working and Writing					
Module nr. 18-pe-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Marius Pesavento		

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
18-pe-1001-ps	Scientific working and writing		
Instructor Prof. Dr.-Ing. Marius Pesavento		**Type** Introductory seminar course	**SWS** 2

Module name					
Scientific Working and Writing					
Module nr. 18-pr-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Sascha Preu		

1 Teaching content

Content and goals

- Elaboration of a technical topic in cooperation with a research associate as supervisor
- Detailed study of technical articles
- Deeper understanding of the technical topic treated therein
- Practical experience with technical documentation
- Learning modern presentation techniques and their application
- Presentation and discussion of the technical topic in front of a group of people

2 Learning objectives

The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B.Sc. etit, B.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

9 References

Suggestions will be provided upon definition of the topic.

Courses

Course nr.	Course name		
18-pr-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sascha Preu		Introductory seminar course	2

Module name Scientific Working and Writing					
Module nr. 18-sc-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr. rer. nat. Sebastian Schöps		

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
18-sc-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sebastian Schöps		Introductory seminar course	2

Module name Scientific Working and Writing					
Module nr. 18-sm-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Björn Scheuermann		

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Depending on specific topic (selected articles of journals, magazines, and conferences).

Courses

Course nr.	Course name		
18-sm-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Björn Scheuermann, M.Sc. Pratyush Agnihotri, Prof. Dr.-Ing. Ralf Steinmetz		Introductory seminar course	2

<table>
<tr><td colspan="6">Module name
Scientific Working and Writing</td></tr>
<tr><td>Module nr.
18-st-1001</td><td>Credit points
3 CP</td><td>Workload
90 h</td><td>Self-study
60 h</td><td>Module duration
1 Term</td><td>Module cycle
Every Semester</td></tr>
<tr><td colspan="3">Language
German/English</td><td colspan="3">Module owner
Prof. Dr. rer. nat. Florian Steinke</td></tr>
</table>

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

<table>
<tr><td>Course nr.
18-st-1001-ps</td><td colspan="3">Course name
Scientific working and writing</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. rer. nat. Florian Steinke</td><td>Type
Introductory seminar course</td><td>SWS
2</td></tr>
</table>

Module name Scientific Working and Writing					
Module nr. 18-su-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to assess the reliability of information sources, comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/sst-s

Courses

Course nr.	**Course name**		
18-su-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Andreas Schürr		Introductory seminar course	2

Module name Scientific Working and Writing					
Module nr. 18-zh-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Li Zhang		

1	**Teaching content** **Content and goals** • Elaboration of a technical topic in cooperation with a research associate as supervisor • Detailed study of technical articles • Deeper understanding of the technical topic treated therein • Practical experience with technical documentation • Learning modern presentation techniques and their application • Presentation and discussion of the technical topic in front of a group of people
2	**Learning objectives** The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
18-zh-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Li Zhang		Introductory seminar course	2

Module name Scientific Working and Writing					
Module nr. 18-zo-1001	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language English			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir		

1 Teaching content

Content and goals

- Elaboration of a technical topic in cooperation with a research associate as supervisor
- Detailed study of technical articles
- Deeper understanding of the technical topic treated therein
- Practical experience with technical documentation
- Learning modern presentation techniques and their application
- Presentation and discussion of the technical topic in front of a group of people

2 Learning objectives

The students are able to comprehend and analyze scientific texts, present technical facts in an orderly manner and present them in a structured manner. Using the example of an original work, they can correctly summarize it in writing and refer to its contents.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or term paper and/or presentation (in preparation for the thesis). The type of examination will be announced at the beginning of the course.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B.Sc. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

9 References

Literature will be announced individually depending on the chosen topic.

Courses

Course nr.	**Course name**		
18-zo-1001-ps	Scientific working and writing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Abdelhak Zoubir		Introductory seminar course	2

1.5 Project Seminars

Module name EET Design Project					
Module nr. 18-bt-1070	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Yves Burkhardt		

1	**Teaching content** This module consists of two parts. **Part A:** The students build a cycle computer for wheel-hub dynamos that does not have any external energy sources or an external speed sensor. Work steps: 1. Operating behaviour of a wheel-hub dynamo (single-phase alternating current machine) 2. Power electronic circuits for voltage stabilization 3. Circuit technology for speed measurement 4. Microcontroller programming with integration of an LCD display **Part B:** The students get the possibility to design and construct their own fixture, which contains a ball track and a ball elevator mechanism. Therefore dimensional plans have to be understood correctly. Afterwards all components (i.e. circuit board, rails and holders) have to be designed and manufactured within the electronic lab and the workshop, where students work independently with turning, drilling and milling machines. This part allows students to gain practical experience and knowledge in construction, assembling and PCB layout design.
2	**Learning objectives** After the completion of this module, students know the tasks in the electronics development like choice of a suitable circuit, micro controller and setting up a circuit. They know how to interpret drawing and how to perform machining processes accordingly. Additionally, they learn how to create a PCB design. Furthermore, students learn about managing a project, present project results and practiced teamwork.
3	**Recommended prerequisites for participation** Electrical Engineering and Information Technology I & II, General Computer Science I
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

	Detailed textbook • F. Barrett: Arduino I Getting Started, Morgan & Claypool, 2020 • U. Tietze, C. Schenk, E. Gamm: Halbleiter-Schaltungstechnik, Springer, 2019 • J. Dillinger et al.: Fachkunde Metall, Europa-Lehrmittel, 2007

Courses

Course nr.	**Course name**		
18-bt-1070-pj	EET Design Project		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Yves Burkhardt		Project seminar	3

Module name Project Seminar „Drive Systems“					
Module nr. 18-bt-1080	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Yves Burkhardt		

1	**Teaching content** From the tasks published by the department for theses, sub-tasks are derived, which are to be worked on by the students in groups of two to four persons under supervision. The focus of the work can be both theoretical and experimental and includes scientific questions on electrical energy conversion and electrical drive technology.
2	**Learning objectives** After completing the module, students will be able to work independently in a team on scientific problems in one or more areas of electrical energy converters, electrical drive technology and control of electrical drives. They have learned to present project results in written and oral form in compliance with the rules for scientific work.
3	**Recommended prerequisites for participation** Fundamentals on Electrical Engineering, three-phase systems, mechanics; Lecture „Electrical Machines and Drives"
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Depending on the project task; manuscripts from the lectures „Electrical Machines and Drives", „Regelungstechnik 1"

Courses

Course nr.	**Course name**		
18-bt-1080-pj	Project Seminar „Drive Systems“		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Yves Burkhardt		Project seminar	3

Module name Project Seminar Analysis, Measurement and Simulation of electromagnetic set-ups					
Module nr. 18-dg-1090	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1 Teaching content

Analysis, experiment and simulation of exemplary electrical devices, e.g.:

- Single-phase transformer
  - Analytical calculation of various parameters of the transformer
  - Experimental setup with iron yoke and coils, various measurements and experi-ments (e.g. short circuit test, measurements with and without airgap, with and without iron core, etc.)
  - Modeling & simulation of the experimental setup using CST EM Studio
- Cavity resonator
  - Analytical calculation of resonance frequencies
  - Calibration of a network analyzer
  - Measurement of diverse cavity resonators by means of a network analyzer
  - Modeling & simulation of cavity resonators using CST EM Studio
- Electrical motor
  - Analytical calculation of various parameters of the motor
  - Construction of own electrical motor with common household material
  - Optimization of the rotational speed
  - Modeling & simulation of the built motor using CST EM Studio
- Vibrations and beats
  - Analytical calculation of mass-damper-systems and electrical oscillating circuits via differential equations
  - Analytical calculation of coupled oscillating circuits (beat phenomenon)
  - Pendulum experiments and measurements of the frequencies using a cell phone app
  - Comparison between mechanical and electrical oscillating circuits
  - Modeling & simulation of the oscillating circuits using LTSpice or own code
- Cathode-ray tube
  - Analytical calculation of various parameters of the cathode-ray tube
  - Measurement of deflections in the electrical field
  - Plotting, reading and interpreting Lissajous figures
  - Modeling & simulation of Helmholtz coils and cathode-ray tube using CST EM Studio

2 Learning objectives

The students are able to explain the physical working principle, technical implementation and relevance of several exemplary electrical devices. They are able to evaluate analytical models, set up simulation models and carry out measurements for the exemplary setups. They are capable of critically assessing and comparing the results and reporting them in a concise way. They are acquinted with the strengths and weaknesses of theory, simulation and experiment in electrical engineering.

3 Recommended prerequisites for participation

Basic knowledge on electric circuits and electromagnetic fields which is part of, e.g., Electrical Engineering and Information Technology I and Electrical Engineering and Information Technology II

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

<table>
<tr><td></td><td colspan="4">Passing the final module examination</td></tr>
<tr><td>6</td><td colspan="4">Grading
Module exam:
Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td colspan="4">Usability of the module
B.Sc. etit, B.Sc. CE</td></tr>
<tr><td>8</td><td colspan="4">Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td colspan="4">References
Experiment instructions</td></tr>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-dg-1090-pj</td><td colspan="3">Course name
Project Seminar Analysis, Measurement and Simulation of electromagnetic set-ups</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Herbert De Gersem</td><td>Type
Project seminar</td><td>SWS
4</td></tr>
</table>

<table>
<tr><td colspan="6">Module name
Project Seminar Implementation of Power Electronic Systems</td></tr>
<tr><td>Module nr.
18-gt-1030</td><td>Credit points
6 CP</td><td>Workload
180 h</td><td>Self-study
135 h</td><td>Module duration
1 Term</td><td>Module cycle
Every Semester</td></tr>
<tr><td colspan="3">Language
German/English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Gerd Griepentrog</td></tr>
</table>

1	**Teaching content** In an introductory meeting topics according to power electronics and control of drives are given to the students. During the seminary problems can be treated concerning the following topics: • Simulation of basic power electronic systems • Implementing and commissioning of power electronic systems • Suggested topics from the students are welcome The students are working autonomous on the chosen problem. The results are documented in a written report and at the end of the module, a presentation about the problem must be held.
2	**Learning objectives** On completion of the module students will have learned the following: • Familiarization with a given problem • Development of a project plan and its follow-up • Usage of development tools • Practical experience in power electronics and control of drives • Logical presentation of the results in a report • Presentation skills
3	**Recommended prerequisites for participation** Lecture „Leistungselektronik 1“ or „Einführung Energietechnik“ and ggf. „Regelungstechnik I“ or similar
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Definition of project task

Courses

Course nr.	Course name		
18-gt-1030-pj	Project Seminar Implementation of Power Electronic Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Gerd Griepentrog		Project seminar	3

Module name					
Project Seminar Computer Systems					
Module nr. 18-hb-1040	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr.-Ing. Christian Hochberger		

1	**Teaching content** Students elaborate on a research-oriented subject in the area of computer-systems. They present a written documentation and a presentation of the acquired advanced knowledge. They provide a set of alternative solutions to a given problem.
2	**Learning objectives** Students are able to systematically develop design alternatives to a given problem. They learn to acquire the necessary fundamental knowledge in terms of references and terminology.
3	**Recommended prerequisites for participation** Basic knowledge of digital design
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
18-hb-1040-pj	Project Seminar Computer Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Project seminar	4

Module name Project Seminar Integrated Electronic Systems					
Module nr. 18-ho-1060	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Teaching content** Research-oriented project in the domain of Integrated Electronic Systems or Microelectronic System Design, Final Report and Presentation of Results in a Team
2	**Learning objectives** After completion of this module, a student is able to fulfill/implement a given task or project in the domain of Integrated Electronic System design (optionally in a group of students), write a final report and present the results to an audience.
3	**Recommended prerequisites for participation** Lecture Electronic and Integrated Circuits
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Material on the subject will be handed out

Courses

Course nr.	**Course name**		
18-ho-1060-pj	Project Seminar Integrated Electronic Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Project seminar	4

Module name Project Seminar Electrical Power Systems					
Module nr. 18-hs-1090	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1	**Teaching content** Students elaborate on a research-oriented subject in the area of electrical power systems. They present a written documentation and/or a presentation of the acquired advanced knowledge. They provide a set of alternative solutions to a given problem. More information can be found here.
2	**Learning objectives** After successful completion of the module, students have learned how to acquire basic knowledge (literature, terminology) on a research-oriented topic and present it in a summarised form. They have learned to systematically work out alternative solutions to a given problem.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
18-hs-1090-pj	Project Seminar Electrical Power Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jutta Hanson		Project seminar	3

Module name Project Seminar Communication and Sensor Systems					
Module nr. 18-jk-1041	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1	**Teaching content** Investigating and solving specific problems concerning communication and sensor systems (Problems concerning communications engineering, microwave technology, signal processing, sensor networks etc. are possible, topics will be defined out of the recent research topics of the involved labs), working on a a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications for a given task, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions and defending them in an oral discussion including audience.
2	**Learning objectives** Upon successful completion of the module, students will be able to: • the ability to apply methods of communication and sensor systems to practical problems • deep and special knowledge in a particular field of communication and sensor systems (communications engineering), RF technology, signal processing, sensor networks • the skills to find, analyze and evaluate scientific reference papers for a particular topic • the capability to summarize the achieved scientific findings in the form of a concise report • the ability to present and discuss achieved results in the form of a presentation in front of an audience
3	**Recommended prerequisites for participation** Previous knowledge in chosen discipline, e.g. communication technology, signal processing, microwave technology, sensor networks
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be announced in the lecture

Courses

Course nr.	**Course name**		
18-jk-1041-pj	Project Seminar Communication and Sensor Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Jakoby, Dr.-Ing. Martin Schüßler		Project seminar	4

Module name Project Seminar Particle Accelerator Technology					
Module nr. 18-kb-1020	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Harald Klingbeil		

1	**Teaching 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** 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 prerequisites for participation** Good understanding of electromagnetic fields, broad knowledge of different electrical engineering disciplines.
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** Suitable material is provided based on specific problem.

Courses

Course nr.	**Course name**		
18-kb-1020-pj	Project Seminar Particle Accelerator Technology		
Instructor Prof. Dr.-Ing. Harald Klingbeil, M.Sc. Sebastian Orth, M.Sc. Yi Jin, M.Sc. Christoph Wegmann		**Type** Project seminar	**SWS** 4

Module name Project Seminar High-Voltage Technology					
Module nr. 18-kc-1020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr. Myriam Koch		

1	**Teaching content** In this seminar, students plan, construct, commission and document devices from the field of high-voltage test and measurement technology in the form of a development project. The built devices will be used, where possible, to carry out initial scientific investigations. The aim is to work in a similar way to a development department in industry, using processes that are frequently applied today (creation of specifications and requirements, division of the project into sub-projects, naming of responsible persons, definition of "milestones", review meetings, documentation and final presentation). The results are summarized in a written report and a final presentation. The students typically work in small groups.
2	**Learning objectives** After successful completion of the module, the students can apply the methodology of design and development from the very first customer requirements specification up to design and type tests and documentation of equipment in high-voltage technology. They have successfully experienced team work and self-independently developed, built and tested a real device from the beginning.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Depending on actual project

Courses

Course nr.	**Course name**		
18-kc-1020-pj	Project Seminar High-Voltage Technology		
Instructor Prof. Dr. Myriam Koch		**Type** Project seminar	**SWS** 3

Module name					
Project Seminar Communication and Sensor Systems					
Module nr. 18-kl-1041	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Anja Klein		

1	**Teaching content** Investigating and solving specific problems concerning communication and sensor systems. Topics will be defined out of the recent research topics of theresearch group. Working on a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications for a given task, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions and defending them in an oral discussion including audience.
2	**Learning objectives** Upon successful completion of the module, students will be able to: • the ability to apply methods of communication and sensor systems to practical problems • deep and special knowledge in a particular field of communication and sensor systems • the skills to find, analyze and evaluate scientific reference papers for a particular topic • the capability to summarize the achieved scientific findings in the form of a concise report • the ability to present and discuss achieved results in the form of a presentation in front of an audience
3	**Recommended prerequisites for participation** Previous knowledge in chosen discipline of communication and sensor systems
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be announced in the lecture

Courses

Course nr.	Course name		
18-kl-1041-pj	Project Seminar Communication and Sensor Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Anja Klein, M.Sc. Sumedh Dongare		Project seminar	4

Module name Project Seminar Communication and Sensor Systems					
Module nr. 18-kp-1041	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr. techn. Heinz Köppl		

1	**Teaching content** Investigating and solving specific problems concerning communication and sensor systems Topics will be defined out of the recent research topics of the research group. Working on a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications for a given task, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions and defending them in an oral discussion including audience.
2	**Learning objectives** Upon successful completion of the module, students will be able to: • the ability to apply methods of communication and sensor systems to practical problems • deep and special knowledge in a particular field of communication and sensor systems • the skills to find, analyze and evaluate scientific reference papers for a particular topic • the capability to summarize the achieved scientific findings in the form of a concise report • the ability to present and discuss achieved results in the form of a presentation in front of an audience
3	**Recommended prerequisites for participation** Previous knowledge in chosen discipline of communication and sensor systems
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be announced in the lecture

Courses

Course nr.	**Course name**		
18-kp-1041-pj	Project Seminar Communication and Sensor Systems		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Heinz Köppl		Project seminar	4

Module name					
Project Seminar Communication and Sensor Systems					
Module nr. 18-pe-1041	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Marius Pesavento		

1 Teaching content

Investigating and solving specific problems concerning communication and sensor systems (Problems concerning communications engineering, microwave technology, signal processing, sensor networks etc. are possible, topics will be defined out of the recent research topics of the involved labs), working on a a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications for a given task, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions and defending them in an oral discussion including audience.

2 Learning objectives

Upon successful completion of the module, students will be able to:

- the ability to apply methods of communication and sensor systems to practical problems
- deep and special knowledge in a particular field of communication and sensor systems (communications engineering), RF technology, signal processing, sensor networks
- the skills to find, analyze and evaluate scientific reference papers for a particular topic
- the capability to summarize the achieved scientific findings in the form of a concise report
- the ability to present and discuss achieved results in the form of a presentation in front of an audience

3 Recommended prerequisites for participation

Previous knowledge in chosen discipline, e.g. communication technology, signal processing, microwave technology, sensor networks

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B.Sc. etit, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

9 References

Will be announced in the lecture

Courses

Course nr.	Course name	
18-pe-1041-pj	Project Seminar Communication and Sensor Systems	
Instructor	**Type**	**SWS**
Prof. Dr.-Ing. Marius Pesavento, M.Sc. Yufan Fan	Project seminar	4

Module name					
Project Seminar Terahertz Systems & Applications					
Module nr. 18-pr-1020	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Sascha Preu		

1	**Teaching content** Investigating and solving specific problems concerning the development of Terahertz devices and systems as well as of applications of THz technology. The specific task will be defined based on current research topics. The project seminar includes working on a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions and defending them in an oral discussion including audience. Topics include, e.g.: • Optics on chip • Semiconductor devicesLight-matter interaction
2	**Learning objectives** Upon successful completion of the module, students were taught: • the ability to apply theoretical models to practical problems • deep and special knowledge in a particular field related to THz science, optics or semiconductor physics • the skills to find, analyze and evaluate scientific reference papers for a particular topic • the capability to summarize the achieved scientific findings in the form of a concise reportthe ability to present and discuss achieved results in the form of a presentation in front of an audience
3	**Recommended prerequisites for participation** Previous knowledge one of the following disciplines: Optics, semiconductor physics, or THz technology
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be announced once the topic is defined

Courses

Course nr.	Course name		
18-pr-1020-pj	Project Seminar Terahertz Systems & Applications		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sascha Preu		Project seminar	2

Module name Project Seminar Communication and Sensor Systems					
Module nr. 18-pr-1041	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Sascha Preu		

1	**Teaching content** Investigating and solving specific problems concerning communication and sensor systems. Topics will be defined out of the recent research topics of the research group. Working on a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications for a given task, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions and defending them in an oral discussion including audience.
2	**Learning objectives** Upon successful completion of the module, students will be able to: • the ability to apply methods of communication and sensor systems to practical problems • deep and special knowledge in a particular field of communication and sensor systems • the skills to find, analyze and evaluate scientific reference papers for a particular topic • the capability to summarize the achieved scientific findings in the form of a concise report • the ability to present and discuss achieved results in the form of a presentation in front of an audience
3	**Recommended prerequisites for participation** Previous knowledge in chosen discipline of communication and sensor systems
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be announced at the beginning of the project.

Courses

Course nr.	**Course name**		
18-pr-1041-pj	Project Seminar Communication and Sensor Systems		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sascha Preu		Project seminar	4

Module name Multimedia Communications Project I					
Module nr. 18-sm-1030	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Ralf Steinmetz		

1 Teaching content

The course deals with cutting-edge development topics in the area of multimedia communication systems. Besides 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 competencies 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
- Adaptive educational technologies
- Natural language processing in education

The concrete list of topics can be found each semester on the corresponding teaching website of KOM.

2 Learning objectives

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 prerequisites 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 exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

	Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, M.Sc. MEC, M.Sc. MedTec, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**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 Seminar I		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing. Julian Zobel, M.Sc. Fridolin Siegmund, Prof. Dr.-Ing. Ralf Steinmetz		Project seminar	4

Module name Project Seminar Electromagnetic CAD					
Module nr. 18-sc-1020	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Sebastian Schöps		

1	**Teaching content** Work on a project in numerical field calculation using commercial tools or own software. Topics of good scientific practice, as well as societal or ethical aspects of product design, optimization, and algorithms are addressed in an accompanying manner, where technically appropriate.
2	**Learning objectives** Students will be able to simulate 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 prerequisites for participation** Good understanding of electromagnetic fields, knowledge about numerical simulation methods.
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, B.Sc. CE, M.Sc. MedTec, M.Sc. iCE
8	**Grade bonus compliant to §25 (2)**
9	**References** Documents will be made available via Moodle if necessary.

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 Energy Information Systems - Computer Engineering					
Module nr. 18-st-1010	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1	**Teaching content** Students elaborate on a research-oriented subject in the area of computer-systems. They present a written documentation and/or a presentation of the acquired advanced knowledge. They provide a set of alternative solutions to a given problem.
2	**Learning objectives** After successful completion of the module, students have learned how to acquire and summarize basic knowledge (literature, terminology) on a research-oriented topic. They have learned to systematically work out alternative solutions to a posed problem from the field of energy information systems/data technology.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
18-st-1010-pj	Project Seminar Energy Information Systems - Computer Engineering		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Florian Steinke		Project seminar	4

Module name					
Project Seminar Energy Information Systems - Electrical Power Engineering					
Module nr. 18-st-1040	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1	**Teaching content** Students elaborate on a research-oriented subject in the area of the energy information networks & systems lab. They present a written documentation and/or a presentation of the acquired advanced knowledge. They provide a set of alternative solutions to a given problem.
2	**Learning objectives** After successful completion of the module, the students have learned how to acquire basic knowledge (literature, terminology) on a research-oriented topic and present it in a summarized form. They have learned to systematically work out alternative solutions to a given problem from the field of energy information systems.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name	
18-st-1040-pj	Project Seminar Energy Information Systems - Electrical Power Engineering	
Instructor	**Type**	**SWS**
Prof. Dr. rer. nat. Florian Steinke	Project seminar	3

Module name					
Projektseminar Software Systems					
Module nr. 18-su-1060	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1 Teaching content

The course deals with various development and research topics in the area of model-driven engineering and object-oriented software engineering. 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:

- Model-Driven Enginnering and Model Synchronization
- Model Transformation
- Object-Oriented Refactorings
- Program Variability (Software Product Lines)
- Feature Model Analysis

2 Learning objectives

The student gains practical experience in development (reengineering and maintenance) of complex software systems. He/She learns to work and function in a team, and to analyze and solve a non- trivial task. Moreover, students exercise using theoretical knowledge in the group (e.g. from lectures like software engineering - introduction / Design / Maintenance & Quality Assurance) to solve a concrete and practical problem.
Students that have successfully completed this seminar are able to independently organize and set-up a non-trivial software project and function to analyze and solve a certain task. Attendees gain the following skills in detail:

- realistic time and resource management (project management)
- experience with tools for version control and change management
- usage of CASE tools for model- based software development
- planning and execution of quality assurance measures

3 Recommended prerequisites for participation

Basic software technology knowledge and advanced knowledge of object-oriented programming languages

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B.Sc. etit, M.Sc. WI-etit, M.Sc. CE, B.Sc. CE, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/ps-softwaresysteme/

Courses

	Course nr.	Course name		
	18-su-1060-pj	Projektseminar Software Systems		
	Instructor		**Type**	**SWS**
	M.Sc. Hendrik Göttmann, Prof. Dr. rer. nat. Andreas Schürr		Project seminar	4

Module name					
Project Seminar Communication and Sensor Systems					
Module nr. 18-zo-1041	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir		

1 Teaching content

Investigating and solving specific problems concerning communication and sensor systems (Problems concerning communications engineering, microwave technology, signal processing, sensor networks etc. are possible, topics will be defined out of the recent research topics of the involved labs), working on a a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications for a given task, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions and defending them in an oral discussion including audience.

2 Learning objectives

Upon successful completion of the module, students will be able to:
- the ability to apply methods of communication and sensor systems to practical problems
- deep and special knowledge in a particular field of communication and sensor systems (communications engineering), RF technology, signal processing, sensor networks
- the skills to find, analyze and evaluate scientific reference papers for a particular topic
- the capability to summarize the achieved scientific findings in the form of a concise report
- the ability to present and discuss achieved results in the form of a presentation in front of an audience

3 Recommended prerequisites for participation

Previous knowledge in chosen discipline, e.g. communication technology, signal processing, microwave technology, sensor networks

4 Form of examination

Module exam:
- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B.Sc. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

9 References

Will be announced in the lecture

Courses

Course nr.	Course name		
18-zo-1041-pj	Project Seminar Communication and Sensor Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Abdelhak Zoubir		Project seminar	4

Module name Product Development Methodology I					
Module nr. 18-sa-1010	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Teaching content** Practical experience in the methods used for the development of technical products. Work in a project team.
2	**Learning objectives** After successful completion of the modul, students are able to apply development methodologies to a concrete development project in a team. They can create a schedule, analyze the state of the art, write a list of requirements, abstract a task and work out sub-problems. They can search for solutions using different solution methods, develop optimal solutions using evaluation methods and derive a reaonable overall concept. The students have learned to derive the required parameters needed by calculation and modeling. They can create manufacturing documentation with all necessary documents such as parts lists, technical drawings and circuit diagrams, carry out the construction and examination of a laboratory sample and reflect retrospectively on the development carried out.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, M.Sc. MEC, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Script: Development Methodology (PEM)

Courses

Course nr.	Course name		
18-sa-1010-pj	Product Development Methodology I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Tran Quoc Khanh, Prof. Dr.-Ing. Klaus Hofmann, M.Sc. Jan Hinrichs, M.Sc. Dominik Großkurth, Prof. Dr. Mario Kupnik, Prof. Ph.D. Thomas Burg, Dr.-Ing. Ferdinand Keil		Project seminar	4

<table>
<tr><td colspan="6">Module name
Product Development Methodology II</td></tr>
<tr><td>Module nr.
18-sa-1020</td><td>Credit points
5 CP</td><td>Workload
150 h</td><td>Self-study
105 h</td><td>Module duration
1 Term</td><td>Module cycle
Summer term</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr.-Ing. Klaus Hofmann</td></tr>
</table>

1	**Teaching 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** 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 prerequisites for participation** Product Development Methodology I
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, M.Sc. MEC, M.Sc. MedTec, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Script: Development Methodology (PEM)

Courses

Course nr.	Course name		
18-sa-1020-pj	Product Development Methodology II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Tran Quoc Khanh, Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr. Mario Kupnik, Prof. Ph.D. Thomas Burg		Project seminar	3

1.6 Modules of the B.Sc. Biomedical Engineering

Please note that the modules of the Biomedical Engineering degree programs can only be selected by students of Biomedical Engineering.

Module name Medizinische Morphologie, Terminologie und Angewandte Anatomie I					
Module nr. 18-mt-1011	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Thomas Vogl		

1	**Teaching content** The module deals with the fundamentals of the morphology of the human body, its tissue structures and their relationships. Basic terminology for naming human anatomy is discussed. Superordinate systemic functional principles within the human body are explained. Basic techniques for representing the human body are presented. The anatomy of the human organs, including the musculoskeletal system, the cardiovascular system, the vascular system and the respiratory tract are discussed, in particular. Anatomical structures and functional relationships are explained on the basis of common clinical cases and thus a direct clinical reference is established. In addition, the participants gain initial knowledge of the organizational structures of diagnostic processes. On the basis of a discussion of medical methods and theoretical approaches in operative disciplines, the participants acquire knowledge on crucial medical issues.
2	**Learning objectives** After successfully completing the module, students are familiar with the basics of medical terminology and the shape and structure of the human body. They are also familiar with different media for obtaining information about the morphology of the body and can assess the medias‘ differential diagnostic reliability. The students are familiar with the basics of the anatomy of important body systems. In addition, the students know important clinical pathologies, can explain them in diagnostics and therapy using examples and discuss them with medical specialists as well as laypersons.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References**

- Caspar: Medizinische Terminologie, Thieme Verlag
- Schünke/Schumacher/Schulte: Prometheus - Lernpaket Anatomie, Thieme Verlag
- Vogl: Diagnostische und Interventionelle Radiologie, Springer Verlag
- Menche: Biologie, Anatomie, Physiologie; Elsevier Verlag
- Supplementary material

Courses

Course nr.	**Course name**		
18-mt-1011-iv	Medizinische Morphologie, Terminologie und Angewandte Anatomie I		
Instructor		**Type**	**SWS**
Prof. Dr. Thomas Vogl		Integrated course	2

Module name Medizinische Morphologie, Terminologie und Angewandte Anatomie II					
Module nr. 18-mt-1012	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. Thomas Vogl		

1	**Teaching content** The module deals with the fundamentals of the morphology of the human body, its tissue structures and their relationships. In particular, the anatomy of the human organs is discussed including the functioning of the lungs, the sensory systems, the digestive system and the nervous system. This also includes the knowledge transfer of medical terminology. Anatomical structures and functional relationships are explained on the basis of common clinical cases and thus a direct clinical reference is established. At the same time, the module discusses methods and devices that can be used to represent the anatomy and functions of the body, such as medical imaging. In addition, the participants gain initial knowledge of the organizational structures of diagnostic processes. On the basis of a discussion of medical methods and theoretical approaches in operative disciplines, the participants acquire knowledge on crucial medical issues.
2	**Learning objectives** Students who have successfully completed this module are familiar with the basics of the anatomy of important body systems and have acquired a deeper understanding of common medical problems, especially in the field of surgery and internal medicine. They are familiar with medical terminology and understand the most important and most common medical terms. In addition, the students know important clinical pathologies, can explain them in diagnostics and therapy using examples and discuss them with medical specialists as well as with laypersons.
3	**Recommended prerequisites for participation** Module „Medical Morphology, Terminology and Applied Anatomy I“
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** • Caspar: Medizinische Terminologie, Thieme Verlag • Schünke/Schumacher/Schulte: Prometheus - Lernpaket Anatomie, Thieme Verlag • Vogl: Diagnostische und Interventionelle Radiologie, Springer Verlag • Menche: Biologie, Anatomie, Physiologie; Elsevier Verlag • Supplementary material
Courses	

	Course nr.	Course name		
	18-mt-1012-iv	Medizinische Morphologie, Terminologie und Angewandte Anatomie II		
	Instructor		**Type**	**SWS**
	Prof. Dr. Thomas Vogl		Integrated course	2

Module name					
Cell Biology and Physiology for Medical Technology I					
Module nr. 18-mt-1021	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 45 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Ingrid Fleming		

1	**Teaching content** This module deals with biological, biochemical and physiological principles that form the basis for the application of engineering methods to living systems in medicine and dentistry. The basics of terminology, cell biology, biochemistry and physiology as well as the principles of physiological and biochemical processes in the human body are taught. In this specific course, basic processes of neuro-, muscle- and cardiovascular physiology are in focus. In parallel, the students are presented with analytical and simple diagnostic procedures linked with common metabolic and organ-specific diseases. Within the framework of the courses, pathophysiological changes leading to common diseases will be presented and discussed to provide a direct link to the clinical situation.
2	**Learning objectives** Students who have successfully completed this module can understand the biological, biochemical and physiological relationships and apply these to the development and evaluation of biomedical diagnostic and therapeutic systems. Furthermore, due to their understanding of cellular and molecular biological processes acquired in this module, students should be prepared to discuss medical content with medical professionals and laypersons as well as to understand basic biomedical literature.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** Menche: Biologie Anatomie und Physiologie, Elsevier-Verlag Accompanying materials

Courses

Course nr.	Course name		
18-mt-1021-iv	Cell Biology and Physiology for Medical Technology I		
Instructor		**Type**	**SWS**
Prof. Dr. Ingrid Fleming		Integrated course	3

Module name Cell Biology and Physiology for Medical Technology II					
Module nr. 18-mt-1022	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 45 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. Ingrid Fleming		

1	**Teaching content** Building on the basic biochemical and physiological topics in the module "Cell Biology and Physiology for Medical Technology 1", the more complex topics of integrative and sensory physiology are taught. Students will be provided insight into the performance of the human sensory organs and the principles of hormonal regulation and metabolism. Building on this, the students are introduced to some pathophysiological functional correlations relevant to common clinical conditions and thus of clinical relevance.
2	**Learning objectives** After successful completion of this module, students should be able to understand basic physiological relationships and apply these to the development and evaluation of biomedical diagnostic and therapeutic systems. On the basis of their understanding of the function of the sensory organs and processes acquired in this module, students should be able to discuss medical content with medical professionals and laypersons, as well as to understand basic biomedical literature.
3	**Recommended prerequisites for participation** Module "Cell Biology and Physiology for Medical Technology I"
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** Mensche: Biologie Anatomie und Physiologie, Elsevier-Verlag Accompanying materials

Courses

Course nr.	**Course name**		
18-mt-1022-iv	Cell Biology and Physiology for Medical Technology II		
Instructor		**Type**	**SWS**
Prof. Dr. Ingrid Fleming		Integrated course	3

Module name					
Biomechanics and Biomaterials					
Module nr. 18-mt-1030	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Ingo Marzi		

1	**Teaching content** This module deals with the basics of biomechanics. Basis for this is the anatomy of the musculoskeletal system. Among these is integrated the introduction into rigid bodies, multi-body models of human body parts, different modeling variants or the determination of the reaction forces and moments in human joints. In addition, this module deals with material sciences for considering the human body and with materials that are used in particular in medical technology. These include medical-grade materials used to make implants that remain temporarily or permanently in the body, as well as biomaterials used to replace body tissues (skin, bones, cartilage, etc.). In the areas of biomechanics and biomaterials, the basics of osteosynthesis techniques with implants and endoprosthetics are presented as well as basic principles of tissue engineering in the fields of medicine and dentistry.
2	**Learning objectives** After successfully completing this module, students gain knowledge and understanding of the biomechanical basis of human body functions. They shall be able to independently and critically use biomechanical methods. Students are familiar with the basic materials and their mechanical and biological properties used in the human body. In particular, students are familiar with the requirement profile for material behavior regarding medical engineering. They are able to independently select materials for an application from medical engineering, to assess their advantages and disadvantages and to explain them in an argumentative manner.
3	**Recommended prerequisites for participation** „Terminology, Medical Morphology and Applied Anatomy“
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 60 Min., Default RS) • Module exam (Technical examination, Examination, Duration: 60 Min., Default RS) Note: one exam per course
5	**Prerequisite for the award of credit points** Passing of Technical examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 50 %) • Module exam (Technical examination, Examination, Weighting: 50 %)
7	**Usability of the module** B.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** Sommerfeld, Klein: Biomechanik der menschlichen Gelenke, Elsevier-Verlag Frobin, Brinckmann, Leivseth: Musculosceletal Biomechanics, Thieme Verlag Grifka, Krämer: Orthopädie-Unfallchirurgie, Springer-Verlag Hausamen: Mund-Kiefer-Gesichtschirurgie, Elsevier-Verlag Epple: Biomaterialien und Biomineralisation, Springer Verlag Curtis, Watson: Dental Biomaterials, Elsevier-Verlag

Courses

	Course nr. 18-mt-1030-iv	**Course name** Biomechanics		
	Instructor Prof. Dr. Ingo Marzi		**Type** Integrated course	**SWS** 3
	Course nr. 18-mt-1031-iv	**Course name** Biomaterials		
	Instructor Prof. Dr. Ingo Marzi		**Type** Integrated course	**SWS** 3

Module name Biomedizinische Technik					
Module nr. 18-mt-1041	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 45 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Dr. Kai Zacharowski		

1	**Teaching content** Biomedical engineering supports medicine with technical solutions in the areas of prevention, diagnostics and therapy. This module focuses on possible applications in the fields of anaesthesiology and radiotherapy. Other disciplines complement the programme at times. In particular, current research and development projects from the field of device technology are taught, taking into account the underlying biotechnology. In addition, anatomy and functional processes in the human body are discussed in the context of common clinical pictures. In the process, the implementation of scientific questions from the basic area and theory into clinical application will be comprehended using practical examples.
2	**Learning objectives** After successful completion of the module, the students have gained insights into the implementation and application of device medical technology and biotechnological processes in application. They are informed about the current R&D status of medical device technology and special biotechnology. In addition, they can independently apply their acquired knowledge to interdisciplinary issues of medicine and engineering sciences and thus formulate subject-related positions.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** Leonhardt, Steffen, Walter, Marian: Medizintechnische Systeme, Springer-Verlag, relevant textbooks and technical articles on the various clinical fields of application, Accompanying materials.

Courses

Course nr.	**Course name**		
18-mt-1041-iv	Biomedizinische Technik		
Instructor		**Type**	**SWS**
Prof. Dr. Dr. Kai Zacharowski		Integrated course	3

Module name					
Biosensorik und Bildgebung					
Module nr. 18-mt-1042	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. Dr. Kai Zacharowski		

1 Teaching content

The Biosensors and Imaging module focuses in particular on methods and devices that can be used to visualise the anatomy and functions of the body. Emphasis is placed on understanding and applying medical imaging and image processing, such as segmentation, filtering and image reconstruction. The use and significance of the various devices and procedures are presented in a problem-oriented manner. This also includes the use of interventional procedures, in which invasive work is carried out on the patient with imaging support. The second focus is on the presentation and application of intracorporeally applied sensory and actuator systems with which minimally invasive body functions are detected and influenced.

2 Learning objectives

After successful completion of the module, the students have gained insights into the implementation and application of device medical technology and biotechnological processes in application. They are informed about the current R&D status of medical device technology and special biotechnology. In addition, they can independently apply their acquired knowledge to interdisciplinary issues of medicine and engineering sciences and thus formulate subject-related positions.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:
- Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)
- Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)

Note: one exam per course

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Technical examination, Examination, Weighting: 50 %)
- Module exam (Technical examination, Examination, Weighting: 50 %)

7 Usability of the module

B.Sc. MedTec

8 Grade bonus compliant to §25 (2)

9 References

Leonhardt, Steffen, Walter, Marian: Medizintechnische Systeme, Springer-Verlag, relevant textbooks and technical articles on the various clinical fields of application, Unterrichtsbegleitende Materialien.

Courses

Course nr.	**Course name**		
18-mt-1042-iv	Biosensors and imaging		
Instructor		**Type**	**SWS**
Prof. Dr. Dr. Kai Zacharowski		Integrated course	2

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-mt-1043-iv</td><td colspan="3">Course name
Bildgebung</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. Thomas Vogl, Prof. Dr. Dr. Kai Zacharowski</td><td>Type
Integrated course</td><td>SWS
2</td></tr>
</table>

Module name Clinical Practical Courses					
Module nr. 18-mt-1120	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 2 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Dr. Robert Sader		

1	**Teaching content** In small groups, students have the opportunity to participate in the everyday clinical practice of various medical disciplines and to experience the use of medical devices in daily use as well as to experience the possibilities and limitations of the device technologies. They participate in various everyday clinical situations in a hospital and learn the clinical communication channels, workflows and treatment strategies.
2	**Learning objectives** Students know the day-to-day work of a physician and the communication structures of a hospital. They understand the terminology and "language" of a medical doctor and can communicate with them sufficiently. They are familiar with a wide range of applications of medical devices and products and are informed about the current state of development of medical devices.
3	**Recommended prerequisites for participation** „Terminology, Medical Morphology and Applied Anatomy“ and „ Natural Scientific Principles for Medical Engineering“ und „Biomedical Engineering“. As well as being vaccinated against measles, mumps, varicella, tetanus and hepatitis B according to the recommendation of the Standing Committee on Vaccinations.
4	**Form of examination** Module exam: • Module exam (Technical examination, Report, p/np RS) After course II the examinee compiles a two-page summary of a medical device, describing functional principle and possible applications but also its limitations in the medical field.
5	**Prerequisite for the award of credit points** Passing of Technical examination
6	**Grading** Module exam: • Module exam (Technical examination, Report, Weighting: 100 %)
7	**Usability of the module** B.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr. 18-mt-1120-pr	**Course name** Clinical Practical Courses I		
Instructor Prof. Dr. Dr. Robert Sader		**Type** Lab	**SWS** 2
Course nr. 18-mt-1121-pr	**Course name** Clinical Practical Courses II		
Instructor Prof. Dr. Dr. Robert Sader		**Type** Lab	**SWS** 2

Module name					
Medical Law, Forensic Medicine and Ethics					
Module nr. 18-mt-1140	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. Markus Parzeller		

1	**Teaching content** This module deals with the legal foundations of the (inter-) national health system and the medical law (among these the medical drug law (AMG), the Civil Code (BGB), the medical device law (MPG), the transplantation law (TPG)) and practical aspects of the forensic medicine (e.g. Forensic toxicology, Forensic DNA, thanatology). It will also cover the basics of medical ethics and bioethics, which will give a closer look to the ethical aspects of research on humans and the development of medical technologies in a legal-ethical context.
2	**Learning objectives** Upon successful completion of this module, students are sensitized to legal and (forensic) medicine issues, current case law in context of medical law and medical technology and ethical aspects in medical engineering and (bio) medicine, including actual and future research projects. They can derive scientifically based judgments that take into account social, legal, scientific, ethical and practical knowledge especially for medical technology.
3	**Recommended prerequisites for participation** None
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing of Module final exam
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** Legal commentariestextbooks and publications of relevant areas of law and of forensic medicine, current case-law from legal databases, ethic basic literature.

Courses

Course nr.	Course name		
18-mt-1140-vl	Medical Law, Forensic Medicine and Ethics		
Instructor Prof. Dr. Markus Parzeller		**Type** Lecture	**SWS** 2

1.7 Mandatory modules of B.Sc. programs from other departments

Module name Mathematics I (Electrical Engineering)					
Module nr. 04-00-0108	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 150 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Apl. Prof. Dr. rer. nat. Steffen Roch		

1	**Teaching content** Basics, real and complex numbers, real funktions, continuity, differential and integral calculus in one variable, vector spaces, linear mappings, systems of linear equations
2	**Learning objectives**
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Default RS) Usually the exam is taken in form of a written test (90 min), except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam (30 min). The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** Für B.Sc.ETiT, B.Ed.ETiT, B.Sc.WIETiT, B. Sc. Mec, B. Sc. CE, B. Sc. IST, B. Sc. MedTech
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
04-00-0126-vu	Mathematics I (Electical Engineering)		
Instructor		**Type**	**SWS**
Apl. Prof. Dr. rer. nat. Steffen Roch		Lecture and practice	6

Module name					
Mathematics II (Electrical Engineering)					
Module nr. 04-00-0109	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 150 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Apl. Prof. Dr. rer. nat. Steffen Roch		

1	**Teaching content** Determinants, eigenvalues, quadratic forms, sequences and series of functions, Taylor and Fourier series, differentiala calculus in R^n, extrema, inverse and implicit functions, path integrals, integration in R^n
2	**Learning objectives**
3	**Recommended prerequisites for participation** Recommended: Mathematik I (für ET)
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Default RS) Usually the exam is taken in form of a written test (90 min), except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam (30 min). The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc.ETiT, B.Ed.ETiT, B.Sc.WIETiT, B. Sc. Mec, B. Sc. CE, B. Sc. IST, B. Sc. MedTech
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
04-00-0079-vu	Mathematics II (Electrical Engineering)		
Instructor		**Type**	**SWS**
Apl. Prof. Dr. rer. nat. Steffen Roch		Lecture and practice	6

<table>
<tr><td colspan="6">Module name
Mathematics III (Electrical Engineering)</td></tr>
<tr><td>Module nr.
04-00-0111</td><td>Credit points
8 CP</td><td>Workload
240 h</td><td>Self-study
150 h</td><td>Module duration
1 Term</td><td>Module cycle
Winter term</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Apl. Prof. Dr. rer. nat. Steffen Roch</td></tr>
</table>

1	**Teaching content** integral calculus: surface integrals, integral theorems; ordinary differential equations: linear and non-linear differential equations, existence and uniqueness of solutions, elementary techniques, linear systems with constant coefficients, Laplace transform; Complex Analysis: complex functions, complex differentiation, Cauchy's integral formula, power series and Laurent series, residues, residue theorem
2	**Learning objectives**
3	**Recommended prerequisites for participation** Recommended: Mathematik I und Mathematik II (für ET)
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Default RS) Usually the exam is taken in form of a written test (90 min), except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam (30 min). The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc.ETiT, B.Ed.ETiT, B.Sc.WIETiT, B. C. MedTech, B.Sc.MEC, B.Sc.CE, B.Sc.IST
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
04-00-0127-vu	Mathematics III (Electrical Engineering)		
Instructor		**Type**	**SWS**
Apl. Prof. Dr. rer. nat. Steffen Roch		Lecture and practice	6

<table>
<tr><td colspan="6">Module name
Statistics/Probability Theory</td></tr>
<tr><td>Module nr.
04-10-0602</td><td>Credit points
4 CP</td><td>Workload
120 h</td><td>Self-study
75 h</td><td>Module duration
1 Term</td><td>Module cycle
Summer term</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr. rer. nat. Stefan Ulbrich</td></tr>
<tr><td>1</td><td colspan="5">Teaching content</td></tr>
<tr><td>2</td><td colspan="5">Learning objectives</td></tr>
<tr><td>3</td><td colspan="5">Recommended prerequisites for participation</td></tr>
<tr><td>4</td><td colspan="5">Form of examination
Module exam:
• Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)</td></tr>
<tr><td>5</td><td colspan="5">Prerequisite for the award of credit points
Passing the final module examination</td></tr>
<tr><td>6</td><td colspan="5">Grading
Module exam:
• Module exam (Technical examination, Examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td colspan="5">Usability of the module</td></tr>
<tr><td>8</td><td colspan="5">Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td colspan="5">References</td></tr>
<tr><td colspan="6">Courses</td></tr>
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<table>
<tr><td rowspan="2"></td><td>Course nr.
04-10-0602-vu</td><td colspan="3">Course name
Statistics/Probability Theory</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Lecture and practice</td><td>SWS
3</td></tr>
</table>

Module name Physics (EE)					
Module nr. 05-91-1033	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr. rer. nat. Joachim Enders		

1	**Teaching content** Mechanics: Basics, force, momentum, work, energy, rigid-body mechanics; Fundamentals of thermodynamics: Temperature, 1st law, heat transport; Oscillations and waves: mechanical and electrodynamic; Optics: Geometrical optics, wave and quantum optics, laser; Fundamentals of quantum physics: quanta, uncertainty relation, atomic structure
2	**Learning objectives** Students know selected fundamental concepts and experimental methods in classical and modern physics with respect to topics in mechanics, thermodynamics, electromagnetic fields and waves, optics, and the structure of matter, are capable of reconstructing analogies between these areas of physics, of understanding the fundamental process of physical reasoning, are competent to apply their fundamental understanding of physics to specific problems by developing quantitative and qualitative solutions indepently, are capable of understanding technical applications as well as phenomena in nature based on their knowledge.
3	**Recommended prerequisites for participation** none
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)
5	**Prerequisite for the award of credit points** Passed examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. Elektrotechnik und Informationstechnik (mandatory), B.Sc. Medizintechnik (mandatory), B.Sc. Angewandte Mechanik (mandatory)
8	**Grade bonus compliant to §25 (2)**

9	**References** Hering, Martin, Stohrer: Physik für Ingenieure (Springer) Demtröder: Experimentalphysik 1, Experimentalphysik 2, Experimentalphysik 3 (Springer) Gerthsen: Physik (Springer) Giancoli: Physics: Principles with Applications (Pearson) Halliday, Resnick, Walker: Fundamentals of Physics (Wiley) Tipler, Mosca, Physics for Scientists and Engineers (W.H. Freeman)

Courses

	Course nr. 05-11-0223-vl	**Course name** Physik für ET		
	Instructor		**Type** Lecture	**SWS** 3
	Course nr. 05-13-0223-ue	**Course name** Physik für ET		
	Instructor		**Type** Practice	**SWS** 2

<table>
<tr><td colspan="6">Module name
General Computer Science I</td></tr>
<tr><td>Module nr.
20-00-0304</td><td>Credit points
6 CP</td><td>Workload
180 h</td><td>Self-study
150 h</td><td>Module duration
1 Term</td><td>Module cycle
Summer term</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr. rer. nat. Karsten Weihe</td></tr>
</table>

<table>
<tr><td>1</td><td>Teaching content</td></tr>
<tr><td>2</td><td>Learning objectives
Basic Knowledge of Computer Science Concepts
Practical Work with computers
Fundamental Programming Skills</td></tr>
<tr><td>3</td><td>Recommended prerequisites for participation
-</td></tr>
<tr><td>4</td><td>Form of examination
Course related exam:
[20-00-0304-iv] (Technical examination, Oral/written examination, Default RS)</td></tr>
<tr><td>5</td><td>Prerequisite for the award of credit points
Pass exam (100%)</td></tr>
<tr><td>6</td><td>Grading
Course related exam:
[20-00-0304-iv] (Technical examination, Oral/written examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td>Usability of the module</td></tr>
<tr><td>8</td><td>Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td>References
David J. Barnes und Michael Kölling, Objects First with Java: A Practical Introduction using BlueJ, Fifth edition, Prentice Hall/Pearson Education, 2012, ISBN 978-013-249266-9</td></tr>
</table>

<table>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
20-00-0304-iv</td><td colspan="3">Course name
General Computer Science I</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Integrated course</td><td>SWS
2</td></tr>
</table>

Module name Scientific Computing (EE)					
Module nr. 04-10-0603	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. rer. nat. Stefan Ulbrich		

1	**Teaching content**
2	**Learning objectives**
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
04-10-0603-vu	Scientific Computing		
Instructor		**Type** Lecture and practice	**SWS** 3

Module name Technical Mechanics for Electrical Engineering					
Module nr. 16-26-6400	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Christian Mittelstedt		

1	**Teaching content** Statics: force, moment (torque), free body diagram, equilibrium equations, center of gravity, truss, beams, adhesion and friction. Mechanics of elastic bodies: stress and deformation, tension, torsion, bending. Kinematics: point and rigid body movement. Kinetics: dynamic force and moment equilibrium equations, energy and work, linear oscillators, momentum and angular momentum conservation laws, impact.
2	**Learning objectives** In this course the students will learn the basic concepts of technical mechanics. They should be able to analyze the statics of simple statically determinate planar systems, to carry out elementary elastomechanical calculations of statically determinate and statically indeterminate structures, to describe and analyze movements, and to solve planar motion problems, oscillation and shock phenomena with the laws of kinetics.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References** Markert, Norrick: Einführung in die Technische Mechanik, ISBN 978-3-8440-3228-4 Exercises are embodied in the book. Further reading: Markert: Statik - Aufgaben, Übungs- und Prüfungsaufgaben mit Lösungen, ISBN 978-3-8440-3279-6 Markert: Elastomechanik - Aufgaben, Übungs- und Prüfungsaufgaben mit Lösungen, ISBN 978-3-8440-3280-2 Markert: Dynamik - Aufgaben, Übungs- und Prüfungsaufgaben mit Lösungen, ISBN 978-3-8440-2200-1 Gross, Hauger, Schröder, Wall: Technische Mechanik 1 - 3. Springer-Verlag Berlin (2012-2014). Hagedorn: Technische Mechanik, Band 1 - 3. Verlag Harri Deutsch Frankfurt.
Courses	

	Course nr. 16-26-6400-vl	**Course name** Technical Mechanics for Electrical Engineering		
	Instructor		**Type** Lecture	**SWS** 3
	Course nr. 16-26-6400-ue	**Course name** Technical Mechanics for Electrical Engineering		
	Instructor		**Type** Practice	**SWS** 2

Module name Algorithms and Data Structures					
Module nr. 20-00-0005	**Credit points** 10 CP	**Workload** 300 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. phil. nat. Marc Fischlin		

1	**Teaching content** • data structures: array, list, binary search tree, B-tree, graph representation, hash table, heaps • algorithms: sorting algorithms, string matching, graph traversal, insertion, search, and deletion for data structures, shortest path search, minimal spanning trees • asymptotic complexity: run times, Big O notation, complexity classes P and NP, NP completeness • algorithmic strategies. for example: Divide-and-Conquer, dynamic programming, brute-force, greedy, backtracking, meta heuristics
2	**Learning objectives** Upon successful completion of the module students get to know fundamental data structures and algorithms and the complexity classes P, NP, and NPC. They acquire the abilities to apply fundamental principles of algorithmics and to assess and determine asymptotic complexity. Furthermore, they understand major algorithmic strategies and can apply them.
3	**Recommended prerequisites for participation** Recommended: Prior attendance of "Functional and Object-Oriented Programming Concepts" or a comparable course.
4	**Form of examination** Course related exam: • [20-00-0005-iv] (Study achievement, Oral/written examination, p/np RS) • [20-00-0005-iv] (Technical examination, Oral/written examination, Default RS) See german description.
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0005-iv] (Study achievement, Oral/written examination, Weighting: 0 %) • [20-00-0005-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B. Sc. Informatik B.Sc. Wirtschaftsinformatik JBA Informatik B.Sc. Informationssystemtechnik B.Sc. Computational Engineering Lehramt an Gymnasien - Fach Informatik Bachelor/Master of Education mit beruflicher Fachrichtung oder Unterrichtsfach Informatik May be used in other degree programs.
8	**Grade bonus compliant to §25 (2)** In dieser Veranstaltung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25(2) der 6. Novelle der Allgemeinen Prüfungsbestimmungen der TU Darmstadt und den vom Fachbereich Informatik am 14.07.2022 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.

<table>
<tr><td>9</td><td colspan="3">References
Will be appointed in lecture.</td></tr>
<tr><td colspan="4">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
20-00-0005-iv</td><td colspan="2">Course name
Algorithms and data structures</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Integrated course</td><td>SWS
8</td></tr>
</table>

Module name					
General Computer Science II					
Module nr. 20-00-0290	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. rer. nat. Karsten Weihe		

1 Teaching content

In this course, students learn fundamental algorithms and data structures using advanced concepts of the programming language Java.

Recapitulation Basic Java:
* Variables, Types, Classes, Program Flow
* Inheritance, Abstract Classes, Interfaces
* Arrays and Collections
Advanced Programming Concepts
* Graphical User Interfaces
* Input/Output
* Error Handling and Exceptions
Algorithms and Data Structures
* Recursion
* Sorting algorithms
* Stacks, Lists, Queues,
* Search
* Trees and Graphs

2 Learning objectives

After completion of this course, students are able to
- write larger programs in Java
- use fundamental algorithms and data structures of computer science
- estimate and compare the quality of elementary algorithms with respect to complexity and run-time

3 Recommended prerequisites for participation

General Computer Science I or
- elementary programming skills in Java
- basic knowledge in computer science
- working with computers

4 Form of examination

Course related exam:
- [20-00-0290-iv] (Technical examination, Oral/written examination, Default RS)

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:
- [20-00-0290-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

8 Grade bonus compliant to §25 (2)

9 References

Java lernen mit BlueJ: Eine Einführung in die objektorientierte Programmierung David J. Barnes, Michael Kölling Pearson Studium 4., aktualisierte Auflage, 2009
ISBN-13: 978-3-8689-4001-5

Algorithmen in Java
Robert Sedgewick
Pearson Studium
3. überarbeitete Auflage, 2003
ISBN-13: 978-3-8273-7072-3

Einführung in die Programmierung mit Java Robert Sedgewick, Kevin Wayne Pearson Studium 1. Auflage, 2011
ISBN-13: 978-3-8689-4076-3

Courses

Course nr.	**Course name**		
20-00-0290-iv	General Computer Science II		
Instructor		**Type** Integrated course	**SWS** 4

Module name
Technical Thermodynamics I

Module nr.	**Credit points**	**Workload**	**Self-study**	**Module duration**	**Module cycle**
16-14-5010	6 CP	180 h	105 h	1 Term	Winter term

Language	**Module owner**
German	Prof. Dr.-Ing. Peter Stephan

1 Teaching content
Fundamental terms of thermodynamics; thermodynamic equilibrium and temperature; different forms of energy (internal energy, heat, work, enthalpy); properties and equations of state for gases and incompressible substances; first law of thermodynamics and energy balances for technical systems; second law of thermodynamics and entropy balances for technical systems; exergy analysis; thermodynamic behaviour during phase change; the carnot cycle for power generation or refrigeration; energy efficiency and coefficient of performance; cyclic processes for gas turbines, combustion engines, power plants, refrigerators and heat pumps.

2 Learning objectives
On successful completion of this module, students should be able to:
1. Explain the relationships between thermodynamic properties and the thermodynamic state of a system and apply them within calculations of thermal system behaviour.
2. Distinguish between different types of energy (e.g. work, heat, internal energy, enthalpy) and define them.
3. Analyse technical systems and processes using energy balances and equations of state.
4. Assess energy conversion processes by means of an entropy balance or an exergy analysis.
5. Characterise the thermal behaviour of gases, liquids and solids and corresponding phase change processes.
6. Apply this basic knowledge (1.-5.) to examine machines (turbines, pumps etc.) and processes for energy conversion (combustion engine, power plants, refrigerators, heat pumps).

3 Recommended prerequisites for participation

4 Form of examination
Module exam:
- Module exam (Technical examination, Examination, Duration: 150 Min., Default RS)

5 Prerequisite for the award of credit points
Passing the examination

6 Grading
Module exam:
- Module exam (Technical examination, Examination, Weighting: 100 %)

7 Usability of the module
Bachelor MB Pflicht
Bachelor WI-MB
Master ETiT MFT, Bachelor Mechatronik

8 Grade bonus compliant to §25 (2)

9 References
P. Stephan; K. Schaber; K. Stephan; F. Mayinger: Thermodynamik, Band 1: Einstoffsysteme, Springer Verlag.
Further material (slides, collection of exercises, table of fomulas etc.) is available through the Moodle system of TU Darmstadt.

Courses

	Course nr. 16-14-5010-vl	**Course name** Technical Thermodynamics I		
	Instructor		**Type** Lecture	**SWS** 3
	Course nr. 16-14-5010-gü	**Course name** Technical Thermodynamics I - Group Exercise		
	Instructor		**Type** Group practice	**SWS** 1
	Course nr. 16-14-5010-hü	**Course name** Technical Thermodynamics I		
	Instructor		**Type** Lecture hall practice	**SWS** 1

Module name					
Functional and Object-oriented Programming Concepts					
Module nr. 20-00-0004	**Credit points** 10 CP	**Workload** 300 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. phil. nat. Marc Fischlin		

1 Teaching content

Basic competences in science-based, problem-oriented development of software systems. Introduction to basic terms and principles of computer science. Development of essential programming skills. Understanding the role of abstraction and modeling in the field of computer science.

The main topics are:

- Basic concepts of programming languages
- Foundations of functional programming languages
- Foundations of object-oriented programming languages
- Design and implementation of small software systems
- Basic type systems
- Fundamental data structures and algorithms and their complexity
- Recursion
- Simple I/O
- Basics of testing
- Documenting source code

2 Learning objectives

After successfully completing the module, the students are familiar with the foundations of functional and object-oriented programming languages and they are able to perform the following tasks:

- systematically solve small programming tasks using functional and/or object-oriented programming language concepts;
- perform quality assurance using basic (unit) tests;
- document source code using standard tools.

3 Recommended prerequisites for participation

4 Form of examination

Course related exam:

- [20-00-0004-iv] (Study achievement, Oral/written examination, p/np RS)
- [20-00-0004-iv] (Technical examination, Oral/written examination, Default RS)

See german description.

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:

- [20-00-0004-iv] (Study achievement, Oral/written examination, Weighting: 0 %)
- [20-00-0004-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

	B. Sc. Informatik B.Sc. Wirtschaftsinformatik JBA Informatik B.Sc. Informationssystemtechnik B.Sc. Computational Engineering Lehramt an Gymnasien - Fach Informatik Bachelor/Master of Education mit beruflicher Fachrichtung oder Unterrichtsfach Informatik May be used in other degree programs.
8	**Grade bonus compliant to §25 (2)** In dieser Veranstaltung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. 25(2) der 6. Novelle der Allgemeinen Prüfungsbestimmungen der TU Darmstadt und den vom Fachbereich Informatik am 14.07.2022 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
9	**References** Will be announced in the course.

Courses

Course nr.	**Course name**		
20-00-0004-iv	Functional and Object-oriented Programming Concepts		
Instructor		**Type** Integrated course	**SWS** 8

Module name Parallel programming					
Module nr. 20-00-1152	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner**		

1	**Teaching content** - foundations of parallel systems - parallel architectures - programming models for parallel computing - parallel algorithms - significant practical programming exercises covering the above topics - if necessary introduction to base programming languages
2	**Learning objectives** After successfully attending this course, students understand the foundations of parallel systems and can apply techniques for their correct as well as efficient programming. They can develop and analyze basic applications using parallel programming techniques on selected platforms.
3	**Recommended prerequisites for participation**
4	**Form of examination** Course related exam: • [20-00-1152-iv] (Study achievement, Special form, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of a maximum of two of the following forms is possible. Software development (optional: including submission of source code and testata), written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including testata), colloquium (optional: including presentation), portfolio.
5	**Prerequisite for the award of credit points** Pass Exam (100%).
6	**Grading** Course related exam: • [20-00-1152-iv] (Study achievement, Special form, Weighting: 100 %)
7	**Usability of the module** B.Sc. Computer Science Teacher training at high schools - subject computer science May be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
20-00-1152-iv	Parallel programming		
Instructor		**Type** Integrated course	**SWS** 3

Module name Operating Systems					
Module nr. 20-00-0903	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. phil. nat. Marc Fischlin		

1	**Teaching content** - Introduction to Operating Systems (OS) - Role, purpose and design issues - Processes and Threads - OS structures, process control, abstractions, kernel/user modes and operations, context switching, interrupts - Inter-Process Communication - Message passing IPC, RPC, layers, interfaces, hierarchies - Coordination: Deadlocks - Process coordination, critical sections, deadlock characterization, deadlock detection and recovery, deadlock avoidance - Scheduling/Resource Management - Task ordering, preemptive and non-preemptive scheduling, schedulers and policies, OS implementations - Concurrency: Races, Mutual Exclusions - Critical sections, races, spin locks, synchronization - Programming Abstractions: Semaphores - Semaphores, Monitors - Memory Management - Storage structures, management/replacements approaches, virtual memory, paging, caching, segmentation - I/O - Device management, drivers, segmentation, interrupt handling, DMA - File systems - File systems requirements, design and implementation, file structures, directories, naming, partitions, virtual file systems - Fault Tolerance/Resilience - Fault types, fault handling approaches, reliable message delivery, OS reliability and availability, security issues - Embedded/RT OS - Memory/disk/performance management, recovery, fault-tolerances, real-time aspects - Distributed OS - Distributed computation and communication abstractions, synchronization, coordination, consistency - Virtual Machines - Purpose and types of virtualization, virtual file systems, Hypervisors
2	**Learning objectives** Students will gain an overview on fundamental Operating System concepts consequent to their succesful course attendance. Students are able to discuss approaches to different concepts regarding various technical requirements such as fault tolerance, security and performance. Moreover, students acquire techniques for the creation of operating systems.
3	**Recommended prerequisites for participation** Recommended: "Algorithmen und Datenstrukturen", "Funktionale und objektorientierte Programmierung", "Rechnerorganisation"
4	**Form of examination** Course related exam: • [20-00-0903-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%) Choosing this modul prohibits choosing Modul 20-00-0175 Operating Systems.
6	**Grading** Course related exam: • [20-00-0903-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module**

	B.Sc. Informatik B.Sc. Informationssystemtechnik May be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References** - Modern Operating Systems; A. Tanenbaum, Prentice Hall, ISBN 0-13-813459-6 - Operating System Concepts; Silberschatz et al, John Wiley and Sons, ISBN 0-470-23399-3

Courses

Course nr.	Course name		
20-00-0903-iv	Operating Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Andreas Koch		Integrated course	3

Module name Engineering Mechanics I (Statics)					
Module nr. 16-64-5190	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Martin Oberlack		

1	**Teaching content** Definition of force, general systems of forces and equilibrium of rigid bodies, center of mass, reaction of the supports, statically determined system, trusses, beams, frames, curved beams, work principles, stability and friction.
2	**Learning objectives** On successful completion of this module, students should be able to: 1. Discern and explain the concept of force, moment, and equilibrium. 2. Analyse statically determinate problems independently, i.e. to identify the forces, and determine their attack points and effects, and formulate equilibrium conditions. 3. Ascertain the support reactions in statically determinate systems by means of equilibrium conditions or the principle of virtual work. 4. Compute internal forces and moments in beams and trusses. 5. Determine the center of gravity of a given rigid body. 6. Determine the equilibrium positions of a given movable system and investigate their stability. 7. Analyse static systems including static or kinetic frictions and calculate corresponding forces.
3	**Recommended prerequisites for participation** None
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS) Written exam 90 min
5	**Prerequisite for the award of credit points** Passing the examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** Bachelor MB Pflicht Bachelor WI-MB Bachelor Mechatronik, Computational Engineering, BEd. Metalltechnik
8	**Grade bonus compliant to §25 (2)**
9	**References** Gross, Hauger, Schröder, Wall: Technische Mechanik I: Statik, 4. Auflage 2009, Springer Verlag.

Courses

Course nr.	**Course name**		
16-64-5190-vl	Engineering Mechanics I (Statics)		
Instructor		**Type** Lecture	**SWS** 3

	Course nr. 16-64-5190-gü	Course name Engineering Mechanics I (Statics) - Group Exercise		
	Instructor		**Type** Group practice	**SWS** 2
	Course nr. 16-64-5190-hü	**Course name** Engineering Mechanics I (Statics)		
	Instructor		**Type** Lecture hall practice	**SWS** 1

Module name Engineering Mechanics II (Elastostatics)					
Module nr. 16-61-3011	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Christian Mittelstedt		

1	**Teaching content** Stresses in 2D and 3D representation, deformation and strain rate, Hooke's law, strength hypotheses, bending of beams, deflection curve, shear influence, torsion, energy principles in elastostatics, stability and buckling.
2	**Learning objectives** On successful completion of this module, students should be able to: 1. Analyse statically determined and statically undetermined systems of bars. 2. Describe one-, two- and three-dimensional stress states in a mathematically correct manner and to identify the corresponding prinicipal stresses. 3. Describe arbitrary strain states in a correct manner and to apply the linear elasticity law. 4. Apply Euler-Bernoulli's beam theory and Timoshenko's beam theory in a correct manner, in particular for the determination of the resulting bending and shear deformation and the resulting distribution of moments and transversal forces. 5. Analyse torsion shafts, in particular for a circular cross-section, thin-walled closed cross-sections and thin-walled open cross-sections. 6. Apply the theorem of work balance and the principle of virtual forces, in particular also for statically undetermined systems. 7. Analyse simple stability problems and to apply Euler's buckling cases.
3	**Recommended prerequisites for participation** Engineering Mechanics I (Statics) recommended
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS) Written exam 90 min
5	**Prerequisite for the award of credit points** Passing the examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** Bachelor MB Pflicht Bachelor WI-MB Bachelor Mechatronik, Computational Engineering, BEd. Metalltechnik
8	**Grade bonus compliant to §25 (2)**
9	**References** Gross; Hauger; Schnell; Schröder: Technische Mechanik 2, Elastostatik, Springer Verlag. Gross; Ehlers; Wriggers: Formeln und Aufgaben zur Technischen Mechanik 2, Springer Verlag.
Courses	

	Course nr. 16-61-5010-vl	**Course name** Engineering Mechanics II (Elastostatics)		
	Instructor		**Type** Lecture	**SWS** 3
	Course nr. 16-61-5010-gü	**Course name** Engineering Mechanics II (Elastostatics) - Group Exercise		
	Instructor		**Type** Group practice	**SWS** 2
	Course nr. 16-61-5010-hü	**Course name** Engineering Mechanics II (Elastostatics)		
	Instructor		**Type** Lecture hall practice	**SWS** 1

<table>
<tr><td colspan="6">Module name
Engineering Mechanics III (Dynamics)</td></tr>
<tr><td>Module nr.
16-25-5120</td><td>Credit points
6 CP</td><td>Workload
180 h</td><td>Self-study
90 h</td><td>Module duration
1 Term</td><td>Module cycle
Winter term</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr.-Ing. Bernhard Schweizer</td></tr>
</table>

<table>
<tr><td>1</td><td>Teaching content
Kinematics of points and rigid bodies, relative kinematics, kinetics of rigid bodies, work and energy, vibrations, impact, principles of mechanics (d'Alembert's principle, Lagrange's equations).</td></tr>
<tr><td>2</td><td>Learning objectives
On successful completion of this module, students should be able to:
1. Describe planar and spatial motions of point masses and rigid bodies.
2. Analyse dynamical problems and derive the equations of motion for simple mechanical systems.
3. Apply Newton´s and Euler´s laws in order to solve dynamical problems.
4. Model simple vibration systems and solve simple differential equations.
5. Apply the principles of mechanics.</td></tr>
<tr><td>3</td><td>Recommended prerequisites for participation
Mathematics I, Engineering Mechanics I (Statics) recommended</td></tr>
<tr><td>4</td><td>Form of examination
Module exam:
• Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)</td></tr>
<tr><td>5</td><td>Prerequisite for the award of credit points
Passing the examination</td></tr>
<tr><td>6</td><td>Grading
Module exam:
• Module exam (Technical examination, Examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td>Usability of the module
Bachelor MB Pflicht
Bachelor WI-MB
Bachelor Mechatronik</td></tr>
<tr><td>8</td><td>Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td>References
Markert, R.: Technische Mechanik, Teil B (Dynamik), 2. Auflage, 2009.
Hagedorn, P.: Technische Mechanik, Band 3: Dynamik, 3. Auflage, Verlag Harri Deutsch, Frankfurt 2006.
Hibbeler, R. C.: Engineering Mechanics: Dynamics, 3rd Edition, Prentice Hall, 2004.</td></tr>
</table>

<table>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
16-25-5120-vl</td><td colspan="3">Course name
Engineering Mechanics III (Dynamics)</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Lecture</td><td>SWS
3</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
16-25-5120-gü</td><td colspan="3">Course name
Engineering Mechanics III (Dynamics) - Group Exercise</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Group practice</td><td>SWS
2</td></tr>
</table>

<table>
<tr><td rowspan="2"></td><td>Course nr.
16-25-5120-hü</td><td colspan="3">Course name
Engineering Mechanics III (Dynamics)</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Lecture hall practice</td><td>SWS
1</td></tr>
</table>

Module name System modeling, mechanical components and actuators for mechatronics					
Module nr. 16-24-6410	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Stephan Rinderknecht		

1	**Teaching content** Mechatronic systems and components; modelling; static and dynamic behaviour; simulation and corresponding tools; mechanical components, actuators; synthesis of mechatronic systems.
2	**Learning objectives** On successful completion of this module, students should be able to: 1. Model Mechatronic Systems and their components and to present them by equations and Blockdiagrams. 2. Find results for the static and dynamic behaviour of mechatronic systems with MATLAB and to interpret these results. 3. Describe the mechatronic subsystem process and actuators and explain their function. 4. Evaluate the behaviour of the mechatronic components with focus on mechanical components and actuators that they are prepared for the synthesis of mechatronic systems.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS) Written exam 90 min
5	**Prerequisite for the award of credit points** Passing the examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** Bachelor Mechatronik
8	**Grade bonus compliant to §25 (2)**
9	**References** Lectures notes

Courses

Course nr.	**Course name**	**Instructor**	**Type**	**SWS**
16-24-6410-vl	System modeling, mechanical components and actuators for mechatronics		Lecture	3
16-24-6410-gü	System modeling, mechanical components and actuators for mechatronics		Group practice	1

<table>
<tr><td rowspan="2"></td><td>Course nr.
16-24-6410-hü</td><td colspan="3">Course name
System modeling, mechanical components and actuators for mechatronics</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Lecture hall practice</td><td>SWS
1</td></tr>
</table>

2

2.1 Lectures

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	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1	**Teaching content** Topics covered are: 1. basic properties of non-linear systems, 2. limit cycles and stability criteria, 3. non-linear control of linear systems, 4. non-linear control of non-linear systems, 5. observer design for non-linear systems
2	**Learning objectives** After attending the module, a student is capable of: 1. explaining the fundamental differences between linear and non-linear systems, 2. testing non-linear systems for limit cycles, 3. stating different definitions of stability and testing the stability of equilibria, 4. recalling the pros and cons of non-linear controllers for linear systems, 5. recalling and applying different techniques for controller design for non-linear systems, 6. designing observers for non-linear systems
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 180 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - AUT, M.Sc. MedTec, B.Sc. und M.Sc. iST, M.Sc. etit - VAS

<table>
<tr><td>8</td><td colspan="4">Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td colspan="4">References
Adamy: Systemdynamik und Regelungstechnik III (available for purchase at the FG office)</td></tr>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-ad-2010-vl</td><td colspan="3">Course name
System Dynamics and Automatic Control Systems III</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Jürgen Adamy, Dipl.-Ing. Markus Kramer</td><td>Type
Lecture</td><td>SWS
2</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-ad-2010-ue</td><td colspan="3">Course name
System Dynamics and Automatic Control Systems III</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Jürgen Adamy, Dipl.-Ing. Markus Kramer</td><td>Type
Practice</td><td>SWS
1</td></tr>
</table>

Module name Fuzzy Logic, Neural Networks and Evolutionary Algorithms					
Module nr. 18-ad-2020	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1 Teaching content

Fuzzy systems: basics, rule based fuzzy logic, design methods, decision making, fuzzy control, pattern recognition, diagnosis; Neural networks: basics, multilayer perceptrons, radial basis functions, pattern recognition, identification, control, interpolation and approximation, Neuro-fuzzy: optimization of fuzzy systems, data driven rule generation; Evolutionary algorithms: optimization problems, evolutionary strategies and their applications, genetic programming and its applications

2 Learning objectives

After attending the module, a student is capable of:

- recalling the elements and set-up of standardized fuzzy-logic, neural networks and evolutionary algorithms,
- discussing the pros and cons of certain set- ups of systems from computational intelligence for solving a given problem,
- recognizing situations in which tools taken from computational intelligence can be applied for problem solving,
- creating programs from algorithms taught in the lecture, and
- extending the learned standard procedures in order to solve new problems.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

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

7 Usability of the module

B.Sc. MEC, M.Sc. MEC, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - AUT, M.Sc. MedTec, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit, M.Sc. etit - VAS

8 Grade bonus compliant to §25 (2)

9 References

Adamy: Fuzzy Logik, Neuronale Netze und Evolutionäre Algorithmen, Shaker Verlag (available for purchase at the FG office)

Courses

Course nr.	**Course name**		
18-ad-2020-vl	Fuzzy Logic, Neuronal Networks and Evolutionary Algorithms		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jürgen Adamy		Lecture	2

	Course nr. 18-ad-2020-ue	**Course name** Fuzzy Logic, Neuronal Networks and Evolutionary Algorithms		
	Instructor Prof. Dr.-Ing. Jürgen Adamy, Dipl.-Ing. Kalina Olhofer-Karova		**Type** Practice	**SWS** 1

Module name					
Evolutionary Systems - From Biology to Technology					
Module nr. 18-ad-2050	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1	**Teaching content** theory of biological evolution, introduction to genetics, population genetics, population growth, evolutionary algorithms, applications, DNA computing, artificial life, theory of evolutionary algorithms, optimization algorithms, multi-objective optimization, meta models, co-evolution, genetic coding, representations of evolutionary algorithms, developmental processes, self-adaptation
2	**Learning objectives** After attending the module, a student is capable of: 1. understanding the basic principles of evolutionary biology on a systems level, 2. transferring of this knowledge to the technical domain (evolutionary algorithms), 3. applying evolutionary algorithms to hard optimization problems, 4. gaining insight into the potentials and challenges of interdisciplinary research (natural and engineering/computer science).
3	**Recommended prerequisites for participation** Introductory courses mathematics. Basic computer skills.
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. MEC, M.Sc. MEC, M.Sc. WI-etit, M.Sc. CE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** • D.J. Futuyama: Evolutionary Biology. W. Henning, Genetik, Springer Verlag • D.B. Fogel: Evolutionary Computation, IEEE Press • I. Rechenberg: Evolutionsstrategie ‘94 • H.-P. Schwefel: Evolution and Optimum Seeking

Courses

Course nr.	Course name		
18-ad-2050-vl	Evolutionary Systems - From Biology to Technology		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Bernhard Sendhoff		Lecture	2

Module name Computer Vision in Engineering					
Module nr. 18-ad-2090	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1 Teaching content

A Basics
- Scene Representation 2D and 3D Geomtery
- Image Acquisition
  - Geometric Projections Camera Calibration
- Objective and Illumination
- Discrete 2D signals
  - Separability, Sampling
  - Transformation, Interpolation
  - Convolution, Correlation
  - Discrete Fourier Transformation

B Basics of Image Analysis
- Filtering
  - Basics2D Filter Design
  - Linear Filtering
  - Nichtlinear Filtering
- Image Decompositions
  - Multi-scale Representation
  - Pyramids
  - Filter Banks
- Image Features
  - Structure
  - Moments, Histograms

2 Learning objectives

After successful completion, the module teaches mathematical basics needed to solve computer vision problems in the field of engineering. The focus is on methods that are relevant for measuring and control tasks. Applications range from visual quality inspection, visual robotics, photogrammetry, visual odometry up to visually guided driver assistance etc.

The students should obtain a good understanding for the relations between the three-dimensional world and its two-dimensional projection onto the image plane of a camera. They also should learn about methods that exist to infer knowledge from the world given image data. They should develop some feeling for the different kinds of problems that arise in computer vision and how to choose an efficient solution in terms of algorithms.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:
- Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)

The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 10 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 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

	Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - AUT, M.Sc. MedTec, M.Sc. iCE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** References / Textbooks: Lecture slides, exercise sheets and matlab-code. Further reading 1. Yi Ma, Stefano Soatto, Jana Kosecka und Shankar S. Sastry, An Invitation to 3-D Vision - From Images to Geometric Models, Springer, 2003. 2. Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, 2004. 3. Karl Kraus, Photogrammetrie, Band 1 Geometrische Informationen aus Photographien und Laserscanner-aufnahmen 7. Auflage, de Gruyter Lehrbuch, 2004. 4. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer 2006. 5. Bernd Jähne, Digital Image Processing, 6. Auflage, 2005.

Courses

Course nr.	Course name		
18-ad-2090-vl	Computer Vision in Engineering		
Instructor		**Type**	**SWS**
Dr.-Ing. Thomas Guthier, M.Sc. Frank Ziegler		Lecture	2

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	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1	**Teaching 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** Upon completion of the module, students will have 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 prerequisites for participation** Fundamental knowledge in linear algebra and statistics Preferred: Lecture “Fuzzy logic, neural networks and evolutionary algorithms”
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) 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	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. MEC, M.Sc. MEC, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - AUT, M.Sc. MedTec, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**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 Automated Driving					
Module nr. 18-ad-2110	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1 Teaching content

- History of Automated Driving
- Terminology and Paths towards Automated Driving
- Architectures, Building Blocks, and Components
- Perception & Environment Models
- Data Fusion & State Estimation
  - Deep Dive: Target Tracking & Traffic Participant Fusion
  - Deep Dive: Grid Fusion & Free Space Estimation
  - Deep Dive: Road Model Fusion
- Localization, Digital Maps, and Vehicle-To-X Communication
- Situation Understanding, Prediction, and Criticality Assessment
  - Deep Dive: Probabilistic Driving Maneuver Detection
- Behavior & Trajectory Planning, Decision Making
- Automated Driving Software Development & Test
- Open Challenges & State-of-the-Art Research Topics

2 Learning objectives

Upon successful completion of the module, students will be able to:

- is familiar with the history and terminology of automated driving systems,
- knows important architectures, building blocks, and components of automated vehicles,
- understands different perception, environment model, and data fusion approaches,
- has an idea about relevant methods (e.g. Bayesian Inference & Probabilistic Graphical Models, State Estimation, Deep Learning, Dempster-Shafer Theory) and knows how they can be beneficially applied in different of automated driving areas (e.g. detection, target tracking & traffic participant fusion, grid fusion, road model fusion, localization),
- is familiar with the challenges of situation understanding, prediction, and criticality assessment and knows exemplary methods to tackle the problem,
- is aware of exemplary behavior & trajectory planning approaches,
- knows best practices about automated driving software development & test (e.g. continuous integration, verification & validation, test-driven development, key performance indicators), and
- is familiar with open challenges and research topics.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

	Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. WI-etit, M.Sc. etit - AUT, M.Sc. iCE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Own lecture slides are distributed in advance of any lecture. For more detailed insights into the topic area, the following books can be recommended: • Eskandarian, A.: Handbook of Intelligent Vehicles. Springer, London, 2012. • Siciliano, B.; Khatib, O.: Springer Handbook of Robotics. 2nd Edition, Springer, Berlin Heidelberg 2016. • Thrun, S.; Burgard, W.; Fox, D.: Probabilistic Robotics. Intelligent Robotics and Autonomous Agents. The MIT Press, Cambridge, 2006. • Watzenig, D.; Horn, M.: Automated Driving. Safer and More Efficient Future Driving. Springer, Switzerland, 2017. • Winner, H. et al.: Handbook of Driver Assistance Systems. Basic Information, Components and Systems for Active Safety and Comfort. Springer, Switzerland, 2016.

Courses

Course nr.	Course name		
18-ad-2110-vl	Automated Driving		
Instructor		**Type**	**SWS**
Dr.-Ing. Matthias Schreier		Lecture	2

Module name					
Medical Device Regulation					
Module nr. 18-ad-2120	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1	**Teaching 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** 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 prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**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	

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-ad-2120-vl</td><td colspan="3">Course name
Medical Device Regulation</td></tr>
<tr><td colspan="2">Instructor
Dr.-Ing. Andreas Röse, Dr.rer.nat Olaf Kessel-Deynet</td><td>Type
Lecture</td><td>SWS
2</td></tr>
</table>

Module name Optimization in Multi-Agent Systems					
Module nr. 18-ad-2130	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1 Teaching content

Part I: Classical theory of unconstrained and constrained optimization:

- useful facts from analysis (differentiable functions, gradients, Hessian matrices, convex functions)
- necessary and sufficient conditions of extremum
- unconstrained optimization problem: existence, uniqueness, and stability of solution, gradient descent in convex optimization, its convergence and convergence rate
- Karush-Kuhn-Tucker condition
- optimization subjected to convex simple constraints, gradient projection method and its convergence properties
- optimization subjected to inequality constraints, primal-dual approach, Lagrangian, Arrow-Hurwicz-Uzawa iterative procedure

Part II: Optimization in multi-agent systems: Distributed (cooperative) optimization

- consensus in multi-agent systems, motivating examples
- communication protocols: gossip, weight-balanced communication
- consensus algorithm and its convergence (with the proof for weight-balanced communication)
- distributed optimization problems in multi-agent systems, motivating examples
- gradient-based procedure with weight-balanced communication and its convergence
- constrained distributed optimization (motivating examples, projected gradient-based procedure with weight-balanced communication and its convergence, discussion on the primal-dual approach)
- state of the art (convergence rate discussion, unbalanced communication, modern applications and their challenges)

Part III: Optimization in multi-agent systems: Game-theoretic (non-cooperative) optimization

- general game formulation, examples
- Nash equilibrium concept
- discrete action games, existence of a mixed-strategy Nash equilibrium
- continuous action games (continuous action games with convex cost functions, examples)
- variational inequalities, game mappings, and their connection to Nash equilibria problems in convex games
- existence and uniqueness of Nash equilibrium in convex games
- gradient methods in convex games (convergence in the case of games with strongly monotone mappings, non-convergence in the case of games with purely monotone mappings, regularized algorithms and their convergence)
- state of the art (convergence rate discussion, information settings in the system: communication- and payoff-based methods, modern applications and their challenges)

2 Learning objectives

	Firsly, students refresh the knowledge on the classical results in convex optimization. Next, students deal with two main types of optimization problems in multi-agent systems: cooperative and non-cooperative optimization. Some practical examples are demonstrated. Students learn how to solve cooperative optimization problems by mean of consensus-type communication-based algorithms in the networked multi-agent systems. Moreover, they get insights in the modern applications and current challenges of cooperative optimization. In the case when each agent in a multi-agent system follows the goal to optimize its own objective a so-called non-cooperative game-theoretic optimization problem is formulated in the system. Students are able to formulate this problem, namely to define a game with its main component and solution concepts (action sets, individual cost funtions, Nash equilibria). Further the focus is on continuous action convex games. To find a solution (a Nash equilibrium in a given game), students use the connection between Nash equilibria in games and solutions of the corresponding variational inequalities. Furthemore, students are able to investigate the properties of the game (strongly/strictly monotone, merely monotone game) to apply an appropriate optimization procedure (gradient-based or regularized one) to achieve a solution. Finally, students get insights in different settings of information in the game-theoretic optimization (where only partial information is available to each agent) and know approaches that can be applied in each case.
3	**Recommended prerequisites for participation** Mathematics I, II, III
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. etit - AUT, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** 1. Nedic and A. Ozdaglar "Cooperative Distributed Multi-Agent Optimization" in the book "Convex Optimization in Signal Processing and Communications" by Y. Eldar and D. Palomar 2. F. Facchinei J.-S. Pang "Finite-Dimensional Variational Inequalities and Complementarity Problems"

Courses

Course nr.	Course name		
18-ad-2130-vl	Optimization in Multi-Agent Systems		
Instructor		**Type**	**SWS**
Dr. rer. nat. Tatiana Tatarenko		Lecture	2
Course nr.	**Course name**		
18-ad-2130-ue	Optimization in Multi-Agent Systems		
Instructor		**Type**	**SWS**
Dr. rer. nat. Tatiana Tatarenko		Practice	1

Module name					
Automation Technology in Process Industries					
Module nr. 18-ad-2140	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1 Teaching content

- Fundamentals of process technology
- Instrumentation in process technology
- Actuators for process technology
- Prozessleittechnik
- Plant safety using process control systems

2 Learning objectives

Students will know important process technological machines and apparatus, are able to read P&I diagrams and are aware of requirements for explosion protection. Important automation concepts in process technology are known and students are able to find solutions for similar tasks.
Students are familiar with important techniques to measure physical and chemical properties as well as actuators for plant control and known under which conditions these techniques can be applied in a plant. The for these tasks necessary fundamentals in fluid dynamics are understood and can be applied. The principal design of automation systems in process industry is known. This includes hardware setup, network, human machine interface and CAE system. How to connect field instrumentation to such a system is known. With this knowledge students are able design such systems.
Students know how PID controllers are realized in a distributed control system (DCS) and they know what to consider when a theoretically calculated controller has to be implemented in a DCS.
To ensure plant safety students know how to perform a hazard analysis and they understand the implication of the resulting safety integrity level (SIL) classification on a to be planned automation system. The probability of failure on demand (PFD) calculation is understood and can be applied.

3 Recommended prerequisites for participation

- Fundamentals of electrical engineering
- Fundamentals of automation

4 Form of examination

Module exam:
- Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)

The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 20 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. MEC, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. etit - AUT, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9	**References** • K.F. Früh, U. Maier: Handbuch der Prozessautomatisierung. Oldenbourg Industrieverlag, 6. Auflage 2018 • W. Hemming, W. Wagner: Verfahrenstechnik. Vogel Fachbuch, 12. Auflage 2017 • M. Engshuber, R. Müller: Grundlagen der Verfahrenstechnik für Automatisierungsingenieure. Deutscher Verlag für Grundstoffindustrie, 2. Auflage 1993 • W. Wagner: Regel- und Sicherheitsarmaturen. Vogel Fachbuch 2. Auflage 2023 • ABB Library: Broschüren Mess und Analysentechnik. https://library.abb.com/ • J. Börcsök: Funktionale Sicherheit. VDE-Verlag, 5. Auflage 2021

Courses

Course nr.	Course name		
18-ad-2140-vl	Automation Technology in Process Industries		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jürgen Adamy		Lecture	2

Module name Didactics for Engineers					
Module nr. 18-ad-2300	**Credit points** 2 CP	**Workload** 60 h	**Self-study** 30 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1	**Teaching content** What is didactics? What is methodology? Various didactic models; German educations sys-tem in professional training (Duales System); objectivism and subjectivism; grading; technol-ogy didactics
2	**Learning objectives** Students are able to impart knowledge. A student is, after successful completion of this module, able to understand 1. the difference between didactics an methodology, 2. which didactic models exist, 3. the german educations system in professional training, 4. what important aspects of grading exist.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Pass module final exam
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit
8	**Grade bonus compliant to §25 (2)**
9	**References** slide copies, record, current literature (list will bei provide in lecture)

Courses

Course nr.	Course name		
18-ad-2300-vl	Didactics for Engineers		
Instructor		**Type** Lecture	**SWS** 2

Module name Accelerator Physics					
Module nr. 18-bf-2010	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. Oliver Boine-Frankenheim		

1	**Teaching 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** 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 prerequisites for participation** BSc in ETiT or Physics
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. CE, M.Sc. MedTec, M.Sc. etit - CMEE
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture notes, transparencies

Courses

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

Module name Plasma Physics					
Module nr. 18-bf-2020	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr. Oliver Boine-Frankenheim		

1	**Teaching content** The lecture will cover the following topics: Occurrence of plasma in our environment - definition of a plasma - particle dynamics in em fields - fluid description of a plasma - waves in plasmas - plasma instabilities - kinetic description of a plasma - plasma generation - plasma diagnostics - plasma applications in the industry.
2	**Learning objectives** The fundmental properties of plasmas, waves in plasmas as well as the interaction of electromagnetic fields with plasmas should be worked out and understood by the students during the course of this lecture.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References** The transparencies can be downloaded from the TUCaN site.

Courses

Course nr.	**Course name**		
18-bf-2020-vl	Plasma Physics		
Instructor		**Type**	**SWS**
Prof. Dr. Oliver Boine-Frankenheim		Lecture	2

Module name Applied Superconductivity					
Module nr. 18-bf-2030	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** Prof. Dr. Oliver Boine-Frankenheim		

1 Teaching content

- Basics and modelling of electrical conductivity at DC and RF
- Kamerligh-Onnes experiment, Meissner effect, London equations
- Superconductor state diagram (phase diagram)
- Introduction to Ginzburg-Landau theory (if necessary also: introduction to basic quantum mechanics)
- Typ I / II Superconductor, Flux quantization, Flux vortices
- Superconducting cables
- Superconductor magnetization, Hysteresis, Bean‘s model
- Cooper pairs (briefly: findings of the BCS theory)
- AC superconductivity, two fluid model, RF cavities
- Cooper pair tunneling, Josephson junctions, SQUIDs
- Applications: Magnets in accelerator and medical technology, precision field and current measurements, superconducting motors, generators, and transformers
- Experimental demonstration of high temperature superconductors

2 Learning objectives

The students obtain a phenomenological understanding of superconductivity, which enables them to apply superconductors in engineering practice. Starting from Maxwellian electrodynamics, superconductors are in introduced as perfect conductors at zero frequency. Both their DC and AC properties are discussed. Theory shall be reduced as much as possible. Quantum mechanics is not a requirement for the course, however, simplified quantum mechanical models will be introduced. The focus of the lecture is put on applications, e.g. magnet technology or precision metrology.

3 Recommended prerequisites for participation

Electrodynamics (Maxwell's equations)

4 Form of examination

Module exam:
- Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Technical examination, Oral examination, Weighting: 100 %)

7 Usability of the module

M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - CMEE

8 Grade bonus compliant to §25 (2)

9 References

- W. Buckel, R. Kleiner: „Supraleitung Grundlagen und Anwendungen“; Wiley VCH, 7. Auflage 2013.
- R.G. Sharma; „Superconductivity, Basics and Applications to Magnets“; Springer International Publishing, 2015 (online available).
- H. Padamsee, J. Knobloch, T. Hays: „RF-Superconductivity for Accelerators“; 2nd edition; Wiley VCH Weinheim, 2011.
- P. Seidel (Ed.), „Applied Superconductivity“, Wiley VCH Weinheim, 2015.

Courses

Course nr.	Course name		
18-bf-2030-vl	Applied Superconductivity		
Instructor		**Type**	**SWS**
PD Dr.-Ing. habil. Uwe Niedermayer		Lecture	2

Module name					
Numerical Methods of Accelerator Physics					
Module nr. 18-bf-2050	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr. Oliver Boine-Frankenheim		

1 Teaching content

- Illustration of accuracy requirements on numerical methods using simple examples from accelerator physics
- Methods for numerical field computation of accelerating cavities and magnets
- Stability analysis and eigenvalue problems in accelerator physics
- Methods for particle tracking in electromagnetic fields
- Techniques for sampling beam distribution functions
- Methods for selfconsistent numerical integration of a beam distribution function in electromagnetic fields
- Surrogate modelling for control room applications
- Interactive (python) notebooks and example scripts for every discussed method and application

2 Learning objectives

After successful completion of the module, the students understand basic models of accelerator physics and suitable procedures for their numerical solution and can apply them.

3 Recommended prerequisites for participation

BSc in etit or Physics

4 Form of examination

Module exam:
- Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Technical examination, Oral examination, Weighting: 100 %)

7 Usability of the module

M.Sc. ESE, M.Sc. MedTec

8 Grade bonus compliant to §25 (2)

9 References

Lecture slides and material including example (python) scripts will be available for download. Further literature references will be given over the course of the lectures.

Courses

Course nr.	Course name		
18-bf-2050-vl	Numerical Methods of Accelerator Physics		
Instructor		**Type** Lecture	**SWS** 2

Module name Energy Converters - CAD and System Dynamics					
Module nr. 18-bt-2010	**Credit points** 7 CP	**Workload** 210 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Yves Burkhardt		

1	**Teaching content** Design of cage-rotor and wound-rotor induction machines: Calculation of forces, torque, losses, efficiency, cooling and temperature rise. Transient machine performance of converter-fed dc machines and line-fed and inverter-fed ac machines. Theory is illustrated by examples: Sudden short circuit, load step, run up. For control design transfer functions of machines are derived. In the exercise lessons demonstration examples of power transformer and induction motor design are given. The students design one induction machine in small groups by themselves. Transient performance calculation is trained by using Laplace-Transformation and MATLAB.
2	**Learning objectives** Upon successful completion of the module, students will be able to: • do and explain the electromagnetic design of an induction machine both analytically and with use of computer program, • understand and predict the thermal performance of electrical drives in a simplified way, • calculate the instationary performance of separately excited DC drives • to predict the dynamical performance of AC polyphase machines with space vector theory and use the MATLAB/Simulink package for this purpose.
3	**Recommended prerequisites for participation** Bachelor of Science in Electrical Engineering, Power Engineering or similar
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)** At the beginning of the semester, it will be announced whether there will be homework tests accompanying the lecture that will enable an improvement in grades.
9	**References** Detailed textbook and collection of exercises; Complete set of PowerPoint presentation • W. Leonhard: Control of electrical drives, Springer Vieweg, 2001 • A. Fitzgerald, A. Kusko, C. Kingsley: Electric machinery, McGraw-Hill, 2002 • G. McPherson: An Introduction to Electrical Machines and Transformers, Wiley, 1990 • M. Say: Alternating Current Machines, Wiley, 1983 • M. Say, E. Taylor: Direct Current Machines, Pitman, 1986 • P. Vas: Vector Control of AC Machines, Oxford Univ. Press, 1990 • D. Novotny, T. Lipo: Vector Control and Dynamics of AC Drives, Clarendon, 1996

Courses				
	Course nr. 18-bt-2010-vl	**Course name** Energy Converters - CAD and System Dynamics		
	Instructor Prof. Dr.-Ing. Yves Burkhardt		**Type** Lecture	**SWS** 3
	Course nr. 18-bt-2010-ue	**Course name** Energy Converters - CAD and System Dynamics		
	Instructor Prof. Dr.-Ing. Yves Burkhardt		**Type** Practice	**SWS** 2

Module name Large Generators and High Power Drives					
Module nr. 18-bt-2020	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr.-Ing. Yves Burkhardt		

1	**Teaching content** Design of large electric generators: Special cooling methods with air, hydrogen and water, loss evaluation, especially eddy current losses, and measures to reduce the additional losses. Design of big hydrogenerators up to 800 MVA and turbo generators up to 2000 MVA with design examples. Application of power electronics in large variable speed drives with synchronous motors: Synchronous converter and cyclo-converter. Numerous photographs to illustrate applications, excursion with students to special firms or plants.
2	**Learning objectives** Upon completion of the module, students will have developed an understanding of the design of cooling systems, design principles and operating characteristics of large generators and drives.
3	**Recommended prerequisites for participation** Physics, Electrical Machines and Drives, Electrical Power Engineering
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Detailed textbook with calculated examples; • A. Binder: El. Maschinen u. Antriebe: Grundlagen, Betriebsverhalten, Springer Vieweg, 2017 • A. Binder: El. Maschinen u. Antriebe: Übungsbuch, Springer Vieweg, 2017 • J. Pyrhönen, T. Jokinen, V. Hrabovcova: Design of Rotating Electrical Machines, 2013, Wiley • A. Fitzgerald, C. Kingsley, A. Kusko: Electric machinery, McGraw-Hill, 2003 • W. Leonhard: Control of electrical drives, Springer Vieweg, 2001 • P. Vas: Parameter estimation, condition monitoring, and diagnosis of electrical machines, Clarendon Press, 1993

Courses

Course nr.	**Course name**		
18-bt-2020-vl	Large Generators and High Power Drives		
Instructor		**Type**	**SWS**
Prof. Dr. Georg Traxler-Samek		Lecture	2

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-bt-2020-ue</td><td colspan="3">Course name
Large Generators and High Power Drives</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. Georg Traxler-Samek</td><td>Type
Practice</td><td>SWS
1</td></tr>
</table>

Module name Motor Development for Electrical Drive Systems					
Module nr. 18-bt-2030	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Yves Burkhardt		

1	**Teaching content** For the wide field of the drive technology at low and medium power range from 1 kW up to about 500 kW. . . 1 MW the conventional drives and the current trends of developments are explained to the students. Grid operated and inverter-fed induction drives, permanent-magnet synchronous drives with and without damper cage ("brushless dc drives"), synchronous and switched reluctance drives and permanent magnet and electrically excited DC servo drives are covered. As a "newcomer" in the electrical machines field, the transversal flux machines and modular synchronous motors are introduced.
2	**Learning objectives** Upon successful completion of the module, students will have knowledge of • modern computational methods (e.g. finite elements), • advanced materials (e.g. high energy magnets, ceramic bearings), • innovative drive concepts (e.g. transversal flux machines) and • measurement and experiment techniques
3	**Recommended prerequisites for participation** Lecture “Electrical Machines and Drives”
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** A detailed script is available for the lecture. In the tutorials design of PM machines, switched reluctance drives and inverter-fed induction motors are explained. • A. Binder: El. Maschinen u. Antriebe: Grundlagen, Betriebsverhalten, Springer Vieweg, 2017 • A. Binder: El. Maschinen u. Antriebe: Übungsbuch, Springer Vieweg, 2017 • J. Pyrhönen, T. Jokinen, V. Hrabovcova: Design of Rotating Electrical Machines, 2013, Wiley

Courses

Course nr.	**Course name**		
18-bt-2030-vl	Motor Development for Electrical Drive Systems		
Instructor		**Type**	**SWS**
Dr.-Ing. Andreas Jöckel		Lecture	2

	Course nr.	Course name		
	18-bt-2030-ue	Motor Development for Electrical Drive Systems		
	Instructor		**Type**	**SWS**
	Dr.-Ing. Andreas Jöckel		Practice	1

Module name New Technologies of Electrical Energy Converters and Actuators					
Module nr. 18-bt-2040	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** Prof. Dr.-Ing. Yves Burkhardt		

1 Teaching content

Application of the superconductors for electrical energy converters:

- rotating electrical machines (motors and generators),
- solenoid coils for the fusion research,
- locomotive- and railway transformers,
- magnetic bearings.

Active magnetic bearings (“magnetic levitation”)

- basics of the magnetic levitation technique,
- magnetic bearings for high speed drives in kW to MW range,
- application for high-speed trains with linear drives.

Magneto-hydrodynamic energy conversion:

- physical principle,
- state of the art and perspectives.

Fusion research:

- magnetic field arrangements for contactless plasma inclusion,
- state of the current research.

2 Learning objectives

After completion of the module students have basic knowledge of application of superconductivity in energy systems as well as magnetic levitation, magnetohydrodynamics and fusion technology.

3 Recommended prerequisites for participation

Physics, Electrical Machines and Drives, Electrical Power Engineering

4 Form of examination

Module exam:

- Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

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

7 Usability of the module

M.Sc. MEC, M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

Detailed textbook

- Komarek, P.: Hochstromanwendungen der Supraleitung, Teubner, Stuttgart, 1995
- Buckel, W.: Supraleitung, VHS-Wiley, Weinheim, 1994
- Schweitzer, G.; Traxler, A.; Bleuler, H.: Magnetlager, Springer, Berlin, 1993
- Schmidt, E.: Unkonventionelle Energiewandler, Elitera, 1975

Courses				
	Course nr. 18-bt-2040-vl	**Course name** New Technologies of Electrical Energy Converters and Actuators		
	Instructor Prof. Dr. techn. Dr.h.c. Andreas Binder		**Type** Lecture	**SWS** 2
	Course nr. 18-bt-2040-ue	**Course name** New Technologies of Electrical Energy Converters and Actuators		
	Instructor Prof. Dr. techn. Dr.h.c. Andreas Binder		**Type** Practice	**SWS** 1

<table>
<tr><td colspan="6">Module name
Railway Vehicle Engineering</td></tr>
<tr><td>Module nr.
18-bt-2050</td><td>Credit points
3 CP</td><td>Workload
90 h</td><td>Self-study
60 h</td><td>Module duration
1 Term</td><td>Module cycle
Summer term</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr.-Ing. Yves Burkhardt</td></tr>
</table>

1 Teaching content

From the comprehensive and interdisciplinary domain of the railway technology (vehicle technology, signal and safety technology, construction engineering and railway operating technology) the module picks out the domain of the automotive engineering with the emphasis of the mechanical part. It offers an interrelated introduction into selected chapters of the rail vehicle engineering with special emphasis in the railway-specific technical solutions and procedures. Theoretical basics as well as essential components of the rail vehicle are taught in depth.

2 Learning objectives

After completing the module, students will have developed an understanding of the mechanical and mechanical engineering principles of modern rail vehicles.

3 Recommended prerequisites for participation

Bachelor in Electrical Engineering, Mechatronics or Mechanical Engineering

4 Form of examination

Module exam:
- Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

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

7 Usability of the module

M.Sc. MEC, M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

References/Textbooks:
- Detailed textbook; Filipovic, Z: Elektrische Bahnen. Springer, Berlin, Heidelberg, 1995.
- Obermayer, H.J.: Internationaler Schnellverkehr. Franckh-Kosmos, Stuttgart, 1994.

Courses

<table>
<tr><td>Course nr.
18-bt-2050-vl</td><td colspan="2">Course name
Railway Vehicle Engineering</td></tr>
<tr><td colspan="1">Instructor
Dr.-Ing. Michael Karatas</td><td>Type
Lecture</td><td>SWS
2</td></tr>
</table>

<table>
<tr><td colspan="6">Module name
Numerical simulation of electrothermal processes</td></tr>
<tr><td>Module nr.
18-bt-2070</td><td>Credit points
3 CP</td><td>Workload
90 h</td><td>Self-study
60 h</td><td>Module duration
1 Term</td><td>Module cycle
Winter term</td></tr>
<tr><td colspan="3">Language
German/English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Yves Burkhardt</td></tr>
</table>

1	**Teaching content** As an introduction, the technical and economic significance of electrothermal process technology is presented using selected examples. In the second part of the lecture, electromagnetic, thermophysical and structural mechanics basics are taught, which are necessary to understand the different electrothermal processes. The main part of the lecture covers the application and design of electrothermal processes, such as inductive heating (emphasis), conductive and dielectric heating, and indirect resistance heating. Practical examples are presented and how they are designed using computer-aided programs (FEM-based numerical simulation models) as well as analytical methods. Within the lecture, simulation models are presented live and analyzed together to visualize and explain the interaction of the respective physical sub-areas of process physics.
2	**Learning objectives** Understanding of design and calculation of electrothermal processes and their applications
3	**Recommended prerequisites for participation** B.Sc. Electrical Engineering or Mechatronics
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 80 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture notes; Fasholz, J., Orth, G.: Induktive Erwärmung, RWE Energie AG, Essen, 4. Aufl., 1991; Nacke, B.; Baake, E. (Hsg.): Induktives Erwärmen, Vulkan-Verlag, 2014

Courses

Course nr.	Course name		
18-bt-2070-vl	Numerical simulation of electrothermal processes		
Instructor		**Type**	**SWS**
Dr.-Ing. Jörg Neumeyer		Lecture	2

Module name Electric Railways					
Module nr. 18-bt-2140	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr.-Ing. Yves Burkhardt		

1 Teaching content

The basics of electrical railway traction systems as well as the generation and distribution of electrical power for rail systems will be presented. This includes:

- Mechanics of traction
- Electrical part of traction vehicles
- Converter and motors for electrical traction
- Monitoring systems
- Comparison of different power supply systems
- DC- and AC- systems for light- and heavy rail
- Problems of earthing and earth return currents
- Sub stations, converters, power plants

2 Learning objectives

After completing the module, students will have developed an understanding of the basic concepts of electric traction units and electric traction current systems.

3 Recommended prerequisites for participation

Basic knowledge in electrical machines and drives

4 Form of examination

Module exam:

- Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)

The examination takes place in form of a written exam (duration: 90 minutes) in combination with a presentation.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. MEC, M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

Text book for the lecture.

- Bendel, H. u.a.: Die elektrische Lokomotive. Transpress, Berlin, 1994.
- Filipovic, Z: Elektrische Bahnen. Springer, Berlin, Heidelberg, 1995.
- Steimel, A.: Elektrische Triebfahrzeuge und ihre Energieversorgung. Oldenburg Industrieverlag, 2006.
- Bäzold, D. u.a.: Elektrische Lokomotion deutscher Eisenbahnen. Alba, Düsseldorf, 1993.
- Obermayer, H. J.: Internationaler Schnellverkehr. Franckh-Kosmos, Stuttgart, 1994.
- Guckow, A.; Kiessling, F.; Puschmann, R.: Fahrleitungen el. Bahnen. Teubner, Stuttgart, 1997.
- Schaefer, H.: Elektrotechnische Anlagen für Bahnstrom. Eisenbahn-Fachverlag, Heidelberg, 1981.

Courses

	Course nr.	Course name		
	18-bt-2140-vl	Electric Railways		
	Instructor		**Type** Lecture	**SWS** 3

Module name					
Electrical Drive Systems for E-Mobility					
Module nr. 18-bt-2150	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Yves Burkhardt		

1 Teaching content

This course introduces the students the requirements for electric drive systems for e-mobility, concepts and components of electric drive systems, derivation of system requirements to individual components, electric motors for e-mobility and their design, system effects in the interaction between motor, converter and transmission as well as knowledge of auxiliary drives in the automobile.

2 Learning objectives

On successful completion of this module, students will be able to

- Explain the common powertrain configurations of hybrid and electric vehicles,
- Understand and analyse the requirements and their implications for the design of electric powertrain systems and components,
- Understand and be able explain the individual components of electric powertrain systems as well as integration and cooling concepts and how they operate,
- Understand and be able to explain typical electrical machines for electrical drive systems, their characteristics and basic selection and design steps,
- Understand and interpret the system effects in the interaction of motor, converter and gearbox in the electric drive system.
- explain the auxiliary drives in passenger cars

3 Recommended prerequisites for participation

Mathematics I to III, Electrical Engineering and Information Technology I and II, Physics, Mechanical Engineering.

4 Form of examination

Module exam:

- Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)

5 Prerequisite for the award of credit points

Pass module final exam

6 Grading

Module exam:

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

7 Usability of the module

M.Sc. MEC, M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

At the beginning of the semester, it will be announced whether there will be short tests accompanying the lecture that will enable an improvement in grades.

9 References

- A. Binder: El. Maschinen u. Antriebe: Grundlagen, Betriebsverhalten, Springer Vieweg, 2017
- R. Fischer: Elektrische Maschinen, Carl Hanser Verlag, 2017
- G. Müller, B. Ponick: El. Maschinen: 1: Grundlagen, 2014; 2: Berechnung, 2007, Wiley-VCH

Courses

	Course nr. 18-bt-2150-vl	**Course name** Electrical Drive Systems for E-Mobility		
	Instructor Prof. Dr. Annette Mütze, Prof. Dr.-Ing. Yves Burkhardt		**Type** Lecture	**SWS** 3
	Course nr. 18-bt-2150-ue	**Course name** Electrical Drive Systems for E-Mobility		
	Instructor Prof. Dr. Annette Mütze, Prof. Dr.-Ing. Yves Burkhardt		**Type** Practice	**SWS** 1

Module name Microsystem Technology					
Module nr. 18-bu-2010	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Ph.D. Thomas Burg		

1	**Teaching content** Students are able to explain the structure and function of microsystemes for common applications (e.g. pressure sensors, accelerometers, biological and chemical sensors, micro-optical systems), calculate design parameters to achieve given specifications, and to judge the impact of scaling on the device performance. They can select appropriate materials, devise basic fabrication process flows, and identify compatibility issues between processes and/or materials.
2	**Learning objectives** Students are able to explain the structure and function of microsystemes for common applications (e.g. pressure sensors, accelerometers, biological and chemical sensors, micro-optical systems), calculate design parameters to achieve given specifications, and to judge the impact of scaling on the device performance. They can select appropriate materials, devise basic fabrication process flows, and identify compatibility issues between processes and/or materials.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. MedTec, M.Sc. iCE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)** Up to 1.0 depending on problem sets and course participation
9	**References** Lecture notes, Moodle course

Courses

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

Module name Lab-on-Chip Systems					
Module nr. 18-bu-2030	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Ph.D. Thomas Burg		

1	**Teaching 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** 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 prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) 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	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - SAE, M.Sc. MedTec, M.Sc. iCE
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture notes and reading assignments on Moodle.
Courses	

	Course nr. 18-bu-2030-vl	**Course name** Lab-on-Chip Systeme		
	Instructor Prof. Ph.D. Thomas Burg		**Type** Lecture	**SWS** 2
	Course nr. 18-bu-2030-ue	**Course name** Lab-on-Chip Systems		
	Instructor Prof. Ph.D. Thomas Burg		**Type** Practice	**SWS** 2

Module name Time domain methods for electromagnetic field simulation					
Module nr. 18-dg-2020	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Teaching content** Finite Difference, Finite Volume and Finite Element Methods for the solution of Maxwell equations in the time domain. High order Discontinuous Galerkin methods. Stability and convergence analysis. High performance computing. Particle based simulations for beams and plasmas.
2	**Learning objectives** Students lern the theoretical basis of advanced simulation techniques for time dependent electromagnetic fields. Furthermore, the lecture mediates practical skills for the implementation, analysis and application of simulation codes for common problems of Electrical Engineering
3	**Recommended prerequisites for participation** Maxwell's equations, infinitesimal calculus, vector calculus. Basics of differential equations and linear algebra
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. CE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture slides, matlab scripts, various literature sources

Courses

Course nr.	**Course name**		
18-dg-2020-vl	Time domain methods for electromagnetic field simulation		
Instructor		**Type**	**SWS**
Privatdozent Dr. rer. nat. Erion Gjonaj		Lecture	2

Module name Electromagnetics and Differential Forms					
Module nr. 18-dg-2030	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Teaching content** In the recent years, the amount of literature that deals with physical models in terms of differential forms (DF) has increased strongly. For instance, DF allow a clear and elegant representation of electromagnetics (EM). The operators grad, curl, and div of vector analysis are replaced by a single operator of the exterior derivative. Similarly, the integral theorems of Gauss and Stokes are replaced by a single integral theorem. Vector analysis is limited to three dimensions, while DF can be applied to any dimensions. This is useful for the relativistic formulations in four dimensions. Since DF can be canonically integrated over appropriate domains they lend themselves naturally to discretizations of the finite integration type. This lecture series provides an introduction into DF calculus, and its relation to vector analysis. Maxwell‘s equations and the constitutive relations are expressed in terms of DF, and the main steps into discretization are outlined briefly.
2	**Learning objectives** Students will acquire a detailed understanding of how to describe EM in terms of DF. • How “space” (and “time”) can be modelled by differentiable manifolds; • How a class of physical fields can be represented by differential forms; • How Maxwell's equations and constitutive relations translate into the language of DF; • How this continuous representation can be discretized.
3	**Recommended prerequisites for participation** It is recommended that the students have basic knowledge about • Electromagnetics (Maxwell's equations in differential and integral form; constitutive relations; EM potentials); • Vector analysis (scalar and vector fields; differential operators grad, curl, and div; integral theorems of Gauss and Stokes).
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References**

- M. Fecko: Differential Geometry and Lie Groups for Physicists, Cambridge University Press, 2006
- F. Hehl, Y. Obukhov: Foundations of Classical Electrodynamics, Birkhäuser, 2003
- K. Jänich: Vector Analysis, Springer, 2001

Courses

Course nr.	Course name		
18-dg-2030-vl	Electromagnetics and Differential Forms		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sebastian Schöps, Prof. Dr.-Ing. Stefan Kurz		Lecture	2

Module name X-Ray Free Electron Lasers					
Module nr. 18-dg-2110	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Teaching content** Optical lasers cannot produce x-rays of photons and high-gain free-electron lasers (FELs) are being developed as extremely bright sources of x-ray radiation. The peak brightness of these facilities exceeds that of other sources by more than ten orders of magnitude. FELs produce hard x-ray beams with very high transverse coherence and femtosecond pulse length. These characteristics open up new areas of x-ray science, such as femtosecond time-domain spectroscopy etc. In this course an overview of the basics of FEL physics is given. We start our discussion from basics principles of particle acceleration and synchrotron radiation, consider the electron motion in an undulator and explain the most important steps to derive the high-gain FEL model. The performance of the high-gain FEL in the linear and the non-linear regimes is considered. The self-amplified spontaneous emission (SASE) option is introduced and characterized. We discuss new schemes for enhancing of the FEL performance. The theoretical considerations in the course are partially illustrated by the results of numerical simulations and experiments. The numerical algorithms are shortly discussed.
2	**Learning objectives** The student should understand the basics of physics of free electron lasers.
3	**Recommended prerequisites for participation** Maxwell's equations, integral and differential calculus, vector analysis
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References** The foils of the lecture will be available at: http://www.desy.de/ zagor/lecturesFEL • K. Wille, Physik der Teilchenbeschleuniger und Synchrotron- strahlungsquellen, Teuner Verlag, 1996. • P. Schmüser, M. Dohlus, J. Rossbach, Ultraviolet and Soft X-Ray Free-Electron Lasers, Springer, 2008. • E. L. Saldin, E. A. Schneidmiller, M. V. Yurkov, The Physics of Free Electron Lasers, Springer, 1999.

Courses

Course nr.	**Course name**		
18-dg-2110-vl	X-Ray Free Electron Lasers		
Instructor		**Type**	**SWS**
PD Dr. Igor Zagorodnov		Lecture	2

	Course nr.	Course name		
	18-dg-2110-ue	X-Ray Free Electron Lasers		
	Instructor		**Type**	**SWS**
	PD Dr. Igor Zagorodnov		Practice	1

Module name					
Technical Electrodynamics for iCE					
Module nr. 18-dg-2150	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1 Teaching content

1. Fundamentals of electromagnetic field theory - Maxwell's equations in differential and integral form; Electromagnetic waves: propagation in free space, polarization, reflection/refraction.
2. Numerical solution of electromagnetic field problems - Space discretization with surface and volume meshes; Main numerical algorithms for discrete local approximation of Maxwell's equations; Finite Integration Technique; Time and frequency domain solution methods; Stability, convergence.
3. Practical aspects of electromagnetic simulation - Introduction to accuracy issues; Preprocessing: 3D geometry, computational domain, boundary conditions, electromagnetic field sources; Time vs frequency domain; Postprocessing; Network parameter extraction.
4. Application to typical high-frequency devices: Waveguide / resonator structures, planar structures

2 Learning objectives

Students will understand fundamental principles of wave propagation, guided waves and antennas. They will be able to model microwave components with simulation software tools. They will have experience with state of the art software tools for electromagnetic fields.

3 Recommended prerequisites for participation

Fundamentals of electrodynamics (Grundlagen der Elektrodynamik)

4 Form of examination

Module exam:
- Module exam (Technical examination, Examination, Duration: 180 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

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

7 Usability of the module

M.Sc. CE, M.Sc. iCE

8 Grade bonus compliant to §25 (2)

9 References

Course manuscript
Additional References:
- D.K. Cheng: Field and Wave Electromagnetics. Addison-Wesley, New York, 1992
- C.A. Balanis: Advanced Engineering Electromagnetics. Wiley, New York, 1989
- Andrew F. Peterson et al. Computational Methods for Electromagnetics. Wiley-IEEE Press, 1997.

Courses

	Course nr. 18-dg-2150-vl	**Course name** Technical Electrodynamics for iCE		
	Instructor Prof. Dr. Irina Munteanu, Prof. Dr. Peter Thoma		**Type** Lecture	**SWS** 2
	Course nr. 18-dg-2150-ue	**Course name** Technical Electrodynamics for iCE		
	Instructor Prof. Dr. Irina Munteanu, Prof. Dr. Peter Thoma		**Type** Practice	**SWS** 2

Module name					
Simulation of Beam Dynamics and Electromagnetic Fields in Accelerators					
Module nr. 18-dg-2170	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1 Teaching content

The lecture provides an overview of the numerical modeling of charged particles and electromagnetic fields in accelerators. The focus is on the simulation of collective effects caused by space charge interaction and/or by electromagnetic wake fields. The lecture is aimed at master's students specializing in various fields of electrical engineering and physics. These include electromagnetic field theory, computational engineering, and computational physics and accelerator physics. Contents of the lecture are:

- Particle tracking methods: types of particle methods, relationship to Vlasov model
- Integration of equations of motion: Boris pusher, numerical stability, symplecticity
- Electrostatic PIC: Green functions, FFT and FD methods, charge deposition, field interpolation, spline shape functions
- DC-gun simulation: space charge limited emission - Tracking in the Lorenz frame - Map based tracking methods
- Electromagnetic PIC: FDTD method, charge-conserving current deposition, Boris scheme, low dispersion methods
- Wakefields and impedances: simulation of ultra-relativistic beams - Plasma Wakefield Acceleration - Parallel computing

2 Learning objectives

Upon completion of the module, students will have gained an overview of the numerical modeling of charged particles and electromagnetic fields in accelerators. They have been given a solid foundation in the field of modern simulation techniques in accelerator technology. The students have gained insight into the different simulation tools and know their advantages and disadvantages, as well as the corresponding areas of application.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Technical examination, Oral examination, Weighting: 100 %)

7 Usability of the module

M.Sc. CE, M.Sc. etit - CMEE

8 Grade bonus compliant to §25 (2)

9 References

Courses

	Course nr.	Course name		
	18-dg-2170-vl	Simulation of beam dynamics and electromagnetic fields in accelerators		
	Instructor		**Type**	**SWS**
	Prof. Dr. Oliver Boine-Frankenheim, Privatdozent Dr. rer. nat. Erion Gjonaj		Lecture	2

Module name Finite Element Method					
Module nr. 18-dg-2180	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1 Teaching content

- Fundamentals of the finite element method: weighted residuals, projection methods, variational formulations, weak formulations; finite elements (definitions, classification, first order Whitney element complex, higher order elements); convergence and accuracy.
- Implementation details: data structures, matrix assembly, system solving, postprocessing.
- Application to electromagnetic problems: electrostatics, magnetostatics, stationary currents, magnetoquasistatics, electroquasistatics, wave propagation.

2 Learning objectives

Students will master the theoretical basics of finite element methods. They understand details regarding the implementation of the method for static, quasistatic and propagating fields. They can apply the finite element method in electrical engineering.

3 Recommended prerequisites for participation

Maxwell's equations, infinitesimal calculus, vector calculus, basics of partial differential equations and linear algebra.

4 Form of examination

Module exam:
- Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Technical examination, Oral examination, Weighting: 100 %)

7 Usability of the module

M.Sc. CE, M.Sc. etit - CMEE

8 Grade bonus compliant to §25 (2)

9 References

- Lecture slides.
- Willi Törnig, Michael Gipser, Bernhard Kaspar. Numerische Lösung von partiellen Differentialgleichungen der Technik: Differenzenverfahren, Finite Elemente und die Behandlung großer Gleichungssysteme. Teubner, 1991.
- Rolf Steinbuch. Finite Elemente - Ein Einstieg. Springer, 1998.
- Alain Bossavit. Computational electromagnetism: variational formulations, complementarity, edge elements. Academic Press, 1997.
- Klaus Knothe, Heribert Wessels. Finite Elemente: Eine Einführung für Ingenieure (3. Aufl.). Springer, 1999.
- P. P. Silvester, R. L. Ferrari. Finite Elements for Electrical Engineers, Cambridge Universtity Press, 1991.
- O. C. Zienkiewicz, R. L. Taylor. The finite element method (4. ed.). McGraw-Hill, 1989.

Courses

Course nr.	Course name		
18-dg-2180-vl	Finite Element Method - Lecture		
Instructor		**Type**	**SWS**
Prof. Dr. Irina Munteanu		Lecture	2
Course nr.	**Course name**		
18-dg-2180-pr	Finite Element Method - Laboratory		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Herbert De Gersem		Lab	2

Module name Virtual Prototyping of Electric Drives					
Module nr. 18-dg-2190	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1 Teaching content

- Basics of electric machine theory
- lassification of electric machine types
- Basic principles of electric machine modelling and simulation
- Embedding material models
- Geometry approximation and field modelling
- Field-circuit coupling and transient simulation
- Finite elements for multiphysics
- Optimization methods
- Simulation environments
- Laboratory measurements on electric machines

2 Learning objectives

The students get acquainted with modern techniques for modelling, simulating and optimizing electric machines. They know the strengths and weaknesses of available design tools and are able to critically assess simulation results. They consider electromagnetic fields and their coupling to structural, thermo- and fluiddynamics. They are able to specify the virtual prototyping problem, choose the appropriate simulation tools, set up the models, and eventually solve the problems, including application of modern optimization techniques.

3 Recommended prerequisites for participation

Basics of field and circuit simulation, electromagnetic field theory, basics of partial differential equations and linear algebra.

4 Form of examination

Module exam:
- Module exam (Technical examination, Oral/written examination, Default RS)

The grade consists of a report and a presentation followed by a question and answer session.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. etit - EET, M.Sc. WI-etit, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

- Lecture slides.
- J.P. Bastos, Electromagnetic Modeling by Finite Element Methods, Marcel Dekker Ltd. 2003.
- N. Bianchi, Electrical Machine Analysis Using Finite Elements, Taylor & Francis, 2005.
- J. Frochtze, Finite-Elemente-Methode, Hanser, 2021.
- M. Kaltenbacher, Numerical Simulation of Mechatronic Sensors and Actuators: Finite Elements for Computational Multiphysics, Springer, 2015.
- S. Salon, Finite Element Analysis of Electrical Machines, Kluwer, 1995.

Courses

Course nr.	**Course name**		
18-dg-2190-vl	Virtual Prototyping of Electric Drives - Lecture		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Herbert De Gersem, Prof. Dr. rer. nat. Sebastian Schöps		Lecture	2

Course nr.	**Course name**		
18-dg-2190-pr	Virtual Prototyping of Electric Drives - Laboratory		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Herbert De Gersem, Prof. Dr. Annette Mütze, Prof. Dr. rer. nat. Sebastian Schöps, Prof. Dr. Dr.h.c. Manfred Kaltenbacher		Lab	2

Module name Serious Games					
Module nr. 18-de-2050	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** PD Dr.-Ing. Stefan Göbel		

1	**Teaching content** Introduction to the topic of ""Serious Games"": scientific and technical foundations, application areas and trends. Individual lectures include: • Introduction to Serious Games • Game Development, Game Design • Game Technology, Tools and Engines • Personalization and Adaptation • Interactive Digital Storytelling • Authoring and Content Generation • Multiplayer Games • Game Interfaces and Sensor Technology • Effects, Affects and User Experience • Mobile Games • Serious Games Application Domains and Best Practice Examples The exercise consists of theoretical and practical parts. Students are taught how to use a Game Engine.
2	**Learning objectives** After successfully completing this course the students are able to explain the concept of "Serious Games" and can transfer it to different application domains (like education or health). They can describe the general approach for developing computer games and can apply basic principles of game design, personalisation / adaptation and interactive digital storytelling. Aside from that students are able to sketch out other current research questions regarding Serious Games as well as their solutions.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 8 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	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. CE, B.Sc. CE, M.Sc. iCE, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**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.
9	**References**

	Will be given in lecture.

Courses

Course nr.	Course name		
18-de-2050-vl	Serious Games		
Instructor		**Type**	**SWS**
PD Dr.-Ing. Stefan Göbel		Lecture	3
Course nr.	**Course name**		
18-de-2050-ue	Serious Games		
Instructor		**Type**	**SWS**
PD Dr.-Ing. Stefan Göbel		Practice	1

Module name Control of Distributed Cyber-Physical Systems					
Module nr. 18-fi-2020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** Prof. Dr.-Ing. Rolf Findeisen		

1	**Teaching content** Cyber-physical systems and multi-variable systems: Aspects and fundamentals of multivariable, interconnected, and cyber-physical systems, control & systems theory concepts (stabilizability, controllability, observability, detectability, reachability, resilience, control & estimation of multivariable systems...), systems and graphs, networked control systems (control & estimation over communication networks, control subject to delays/to information loss, security, safety, and privacy), control of interconnected/multi-agent systems (centralized, decentralized & distributed control, consensus, synchronization), hierarchical control (fundamentals, optimization, time scale separation, hierarchical control concepts, optimization based control & real-time optimization)
2	**Learning objectives** The students are familiar with the basic analysis and control methods for multivariable systems, networked control systems, and interconnected systems and their applications. They are able to model and analyse multivariable, interconnected systems, and networked control systems subject to delays, communication loss. Furthermore, they are able to design basic centralized, decentralized, distributed, hierarchical controllers and estimators, as well as controllers to achieve consensus and synchronization control. They are familiar with the concept of time-scale seperation for control and estimation.
3	**Recommended prerequisites for participation** Basic concepts of control theory. Fundamentals of linear algebra, differential and difference equations.
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If less than 25 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - AUT, B.Ed. etit, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**References** • S. Skogestad, I. Postlethwaite, Multivariable Feedback Control, Wiley, 2005. • J. Lunze (Ed.), Control Theory of Digitally Networked Dynamic Systems, Springer, 2014. • J. Lunze. Networked Control of Multi-Agent Systems, Bookmundo Direct, 2019. • M. Mesbahi, M. Egerstedt. Graph Theoretic Methods in Multiagent Networks, Princeton University Press.
Courses	

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-fi-2020-vl</td><td colspan="3">Course name
Control of Distributed Cyber-Physical Systems</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Rolf Findeisen</td><td>Type
Lecture</td><td>SWS
3</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-fi-2020-ue</td><td colspan="3">Course name
Control of Distributed Cyber-Physical Systems</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Rolf Findeisen</td><td>Type
Practice</td><td>SWS
1</td></tr>
</table>

Module name					
Modeling, Simulation, and Optimization					
Module nr. 18-fi-2030	**Credit points** 7 CP	**Workload** 210 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr.-Ing. Rolf Findeisen		

1 Teaching content

Physics-based modeling, modeling of distributed parameter systems, model simplification, linearization, model reduction, numerical integration methods, static and dynamic optimization, parameter optimization, data-driven modeling, machine learning supported modeling.

2 Learning objectives

The students are familiar with different modeling approaches for dynamical systems and can apply those to various fields of applications. They acquire the ability to simulate the dynamical behavior of the modeled systems. They can select and use suitable integration methods. They can perform a model reduction and decompose dynamical systems. They acquire the fundamental knowledge of static and dynamic optimization of systems. The obtain a perspective on data-driven and machine learning supported modeling.

3 Recommended prerequisites for participation

Basic concepts of control theory. Fundamentals of linear algebra.

4 Form of examination

Module exam:

- Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS)

The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 25 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. MEC, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. etit - AUT, B.Sc. und M.Sc. iST, M.Sc. etit - VAS

8 Grade bonus compliant to §25 (2)

9 References

- P.E. Wellstead. Introduction to Physical Systems Modeling. Academic Press.
- L. Grüne, O. Junge. Gewöhnliche Differentialgleichungen. Springer Spektrum.
- G.F. Franklin, J.D. Powell and A. Emnami-Naeini. Feedback Control of Dynamical Systems, Addison-Wesley.
- C.a. Athanasios. Interpolation Methods for Model Reduction. SIAM.

Courses

Course nr.	**Course name**		
18-fi-2030-vl	Modeling, Simulation, and Optimization		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Findeisen, Dr. Ing. Eric Lenz		Lecture	3

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-fi-2030-ue</td><td colspan="3">Course name
Modeling, Simulation, and Optimization</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Rolf Findeisen, Dr. Ing. Eric Lenz</td><td>Type
Practice</td><td>SWS
2</td></tr>
</table>

Module name Model Predictive Control and Machine Learning					
Module nr. 18-fi-2040	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Rolf Findeisen		

1	**Teaching content** *Lecture:* Introduction and basics of optimal control, Linear Quadratic Regulator (LQR) in discrete and continuous time, basics of model predictive control (cost functions, constraints, receding horizon), nominal model predictive control for linear systems, robust and stochastic model predictive control, model predictive control of nonlinear systems, combination of machine learning and model predictive control. *Group work:* In a group project, the students will apply the learned. The group project evolves a review of state of the art for the selected task, the selection of suitable model predictive control approach, and the implementation using python/Matlab. It includes a project report and is concluded by a project presentation.
2	**Learning objectives** The students will understand the basics concepts of model predictive control. Furthermore, they are familiarized with machine learning approaches that can support model predictive controllers and possibly enhance the controller performance. This entails knowledge about theoretical questions such as stability in the nominal case, as well as extensions to the case of uncertain and disturbed systems. The students are enabled to design and implement model predictive controllers based on first principle/physical or data-based/machine learning based models. This entails the setup and design of the control structure as well as the tuning and identification of suitable parameters and cost functions of the controller.
3	**Recommended prerequisites for participation** Basic concepts of control theory. Fundamentals of linear algebra, differential, and difference equations. Knowledge in Python and/or Matlab.
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 25 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - AUT, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)** Yes. Possibility to improve the grade by a group work/exercise.
9	**References**

- J. Rawlings, D. Mayne, and M. Diehl. Model predictive control: theory, computation, and design. Nob Hill Publishing.
- S. Rakovic, and W. Levine. Handbook of Model Predictive Control. Birkhäuser, 2018.

Courses

Course nr.	Course name		
18-fi-2040-vl	Model Predictive Control and Machine Learning		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Findeisen		Lecture	2
Course nr.	**Course name**		
18-fi-2040-ue	Model Predictive Control and Machine Learning		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Findeisen, M.Sc. Maik Pfefferkorn, M. Eng. Hoang Nguyen		Practice	1

Module name					
Machine Learning for Mechatronic and Dynamical Systems					
Module nr. 18-fi-2060	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Rolf Findeisen		

1	**Teaching content** *Lecture:* The lecture introduces the fundamental concepts of machine learning, focusing on applications in mechatronics and dynamical systems, including data-driven and hybrid modeling, simulation, monitoring, planning, decision making, optimization, and control. *Content:* Machine learning in mechatronics and dynamical systems?; basics of machine learning; review of dynamical systems with a machine learning perspective; machine learning - an optimization perspective; regression; feature generation; clustering (regression and non-regression based); support vector machines; Gaussian processes; inference; Neural Networks (feed-forward, recurrent neural networks, training of neural networks, deep-learning); re-enforcement learning; optimal control and re-enforcement learning; machine-learning for embedded systems; safety and reliability of machine learning for dynamical systems; application examples from monitoring, fault detection, simulation, optimization of complex mechatronic systems, robotics, planning, autonomous driving. *Group exercise/group work:* In a group work, the students will apply the learned concepts and methods to mechatronics and dynamical systems problems. The group work involves a review of state-of-the-art methods for the selected task, the selection of suitable machine learning and decision-making methods, and the implementation using Python/Matlab. It includes a project report and a project presentation. The module is offered jointly by Prof. Rolf Findeisen, Prof. Jürgen Adamy, Prof. Jan Peters
2	**Learning objectives** After successful participation in this module, the students can: understand the basics of machine learning, focusing on mechatronic and dynamical systems; select and evaluate machine learning methods for mechatronic and dynamical systems applications; apply machine learning algorithms for modeling, decisions making, planning, monitoring, and control.
3	**Recommended prerequisites for participation** Basic concepts of control theory. Fundamentals of linear algebra, differential, and difference equations. Knowledge in Python and/or Matlab.
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 25 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module**

	M.Sc. MEC, M.Sc. WI-etit, M.Sc. etit - AUT, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)** Yes. Possibility to improve the grade by a group work/exercise.
9	**References** • Brunton, Steven L., and J. Nathan Kutz. Data-driven science and engineering: Machine learning, dynamical systems, and control. Cambridge University Press, 2019. • D. Bertsekas. Reinforcement Learning and Optimal Control. Athena Scientific, 2019. • K. P. Murphy. Probabilistic Machine Learning: An Introduction. MIT Press, 2022.

Courses

Course nr.	Course name	Instructor	Type	SWS
18-fi-2060-vl	Machine Learning for Mechatronic and Dynamical Systems	Prof. Dr.-Ing. Rolf Findeisen	Lecture	2
18-fi-2060-pr	Machine Learning for Mechatronic and Dynamical Systems	Prof. Dr.-Ing. Rolf Findeisen	Lab	2

Module name					
Multivariable and Robust Control					
Module nr. 18-fi-2070	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Rolf Findeisen		

1 Teaching content

- Basics (MIMO systems, SVD, system norms)
- Controller design for multivariable systems
- H2 and H8 Control design in the frequency domain
- Robust Control (uncertainty description, robustness analysis, robust controller design)

2 Learning objectives

The students are able to formulate, analyse, and design controllers for multivariable systems. They are able to express control tasks as H2 and H8 optimization problems, to represent uncertainities of a system in a suitable form and to design a controller which ensures robust stability and robust performance.

3 Recommended prerequisites for participation

System Dynamics and Automatic Control Systems I and II

4 Form of examination

Module exam:

- Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)

The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 25 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. MEC, M.Sc. WI-etit, M.Sc. etit - AUT, B.Sc. und M.Sc. iST, M.Sc. etit - VAS

8 Grade bonus compliant to §25 (2)

9 References

- S. Skogestad, I. Postlethwaite, Multivariable Feedback Control,2. Auflage, 2005, Wiley
- K. Zhou, Essentials of Robust Control, 1998, Prentice-Hall
- O. Föllinger, Regelungstechnik, 11. Auflage, 2013, VDE Verlag

Courses

Course nr.	**Course name**		
18-fi-2070-vl	Multivariable and Robust Control		
Instructor		**Type**	**SWS**
Dr. Ing. Eric Lenz		Lecture	3

	Course nr.	Course name		
	18-fi-2070-ue	Multivariable and Robust Control		
	Instructor		**Type**	**SWS**
	Dr. Ing. Eric Lenz		Practice	1

Module name					
Data-driven Modelling of Dynamic Systems					
Module nr. 18-fi-2081	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Rolf Findeisen		

1 Teaching content

- Important topics of signal processing and stochastics
- Disturbance and excitation signals
- Identification of linear systems
  - Non-parametric identification (Frequency response estimation)
  - Parametric identification (Characteristic values, Output error and equation error minimization, Subspace method, Kalman filter)
  - Recursive methods
  - Closed loop identification
- Basics of data-driven modelling of non-linear systems

2 Learning objectives

The students are taught the fundamental methods of data-driven modelling (identification). Based on assumptions on the system and constraints imposed by the measurements, the students are able to select, parametrize and apply appropriate methods to generate non-parametric and parametric models from the measurement data.

3 Recommended prerequisites for participation

Basics in the field of control engineering (e.g. lecture System Dynamics and Automatic Control Systems I)

4 Form of examination

Module exam:
- Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)

The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 25 students register, the examination will be an oral examination (duration: 90 min.). The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - AUT, B.Sc. und M.Sc. iST, M.Sc. etit - VAS

8 Grade bonus compliant to §25 (2)

9 References

- Pintelon, R.; Schoukens, J.: System Identification: A Frequency Domain Approach. IEEE Press, New York, 2001.
- Ljung, L.: System Identification: Theory for the user. Prentice Hall information and systems sciences series. Prentice Hall PTR, Upper Saddle River NJ, 2. edition, 1999.

Courses

	Course nr.	Course name		
	18-fi-2080-vl	Data-driven Modelling of Dynamic Systems		
	Instructor		**Type**	**SWS**
	Dr. Ing. Eric Lenz		Lecture	2
	Course nr.	**Course name**		
	18-fi-2080-ue	Data-driven Modelling of Dynamic Systems		
	Instructor		**Type**	**SWS**
	Dr. Ing. Eric Lenz		Practice	1

Module name Basics of Biophotonics					
Module nr. 18-fr-2010	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** Prof. Dr. habil. Torsten Frosch		

1	**Teaching content** Review of the fundamentals of optics, laser technology, light-matter interaction, and spectroscopic systems, covering medical applications such as photodynamic therapy and optical heart rate measurement etc.; spectroscopy and imaging with linear optical processes: IR absorption, Raman spectroscopy, with applications e.g. in breath analysis, drug quality control, as well as detection of biomarkers; laser microscopy, e.g. wide-field microscopy, Raman microscopy and chemical imaging, fluorescence microscopy, with applications e.g. in neurostimulation research; spectroscopy and imaging with nonlinear optical processes: fundamentals of nonlinear optics, multiphoton fluorescence, e.g., with application for in vivo imaging of the brain, coherent nonlinear optical processes such as SHG and CARS, multimodal imaging, e.g. with potential application in intra-operative tumor imaging.
2	**Learning objectives** Students get to know established and state of the art biophotonic systems in medical technology and understand the underlying concepts. They are familiar with linear and nonlinear optical processes of light-matter interaction and understand the principles of spectroscopy and microscopy based on them. With the help of the gained knowledge, the students will be able to evaluate and compare common biophotonic methods and instruments. Furthermore, they will be able to recommend appropriate techniques and methods for a particular application.
3	**Recommended prerequisites for participation** Physics for Electrical Engineering and Mathematics I (Electrical Engineering)
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. WI-etit, M.Sc. MedTec, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** • Kramme, Medizintechnik - Chapter Biomedizinische Optik (Biophotonik), Springer • Gerd Keiser, Biophotonics: Concepts to Applications, Springer • Lorenzo Pavesi, Philippe M. Fauchet, Biophotonics, Springer • Jürgen Popp, Valery V. Tuchin, Arthur Chiou, Stefan H. Heinemann, Handbook of Biophotonics, Wiley-VCH
Courses	

	Course nr. 18-fr-2010-vl	**Course name** Basics of Biophotonics		
	Instructor Dr. rer. nat. Andreas Merian, Prof. Dr. habil. Torsten Frosch, M.Sc. Phil Reize		**Type** Lecture	**SWS** 2
	Course nr. 18-fr-2010-ue	**Course name** Basics of Biophotonics		
	Instructor Dr. rer. nat. Andreas Merian, Prof. Dr. habil. Torsten Frosch, M.Sc. Phil Reize		**Type** Practice	**SWS** 1

Module name					
Fundamentals and Technology of Radiation Sources for Medical Applications					
Module nr. 18-gr-2010	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr.-Ing. Christian Graeff		

1 Teaching 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

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 prerequisites for participation

18-kb-1040 Applications of Electrodynamics

4 Form of examination

Module exam:

- Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS)

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 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. CE, M.Sc. MedTec

8 Grade bonus compliant to §25 (2)

9 References

- Strahlungsquellen für Technik und Medizin, Hanno Krieger, Springer (2014)

Courses

	Course nr. 18-gr-2010-vl	**Course name** Fundamentals and technology of radiation sources for medical applications		
	Instructor Prof. Dr.-Ing. Christian Graeff		**Type** Lecture	**SWS** 2
	Course nr. 18-gr-2010-ue	**Course name** Fundamentals and technology of radiation sources for medical applications		
	Instructor Prof. Dr.-Ing. Christian Graeff		**Type** Practice	**SWS** 2

<table>
<tr><td colspan="6">Module name
Ion Beam Therapy</td></tr>
<tr><td>Module nr.
18-gr-2020</td><td>Credit points
4 CP</td><td>Workload
120 h</td><td>Self-study
75 h</td><td>Module duration
1 Term</td><td>Module cycle
Summer term</td></tr>
<tr><td colspan="3">Language
German/English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Christian Graeff</td></tr>
</table>

<table>
<tr><td>1</td><td>Teaching content
Ion Beam Therapy is a cutting edge tool to treat cancer. Ion beams offer unique properties to tailor the dose to deep-seated targets inside the human body, while sparing surrounding healthy tissue. Their finite range, sharp dose gradients and increase radiobiological efficacy offer the potential for improved treatment options, but also pose high demands on precision and further research to be optimally implemented in clinical practice.

This course addresses the following topics:
• Basics of physics and radiobiology of ion beams
• Typical ion beam therapy centers
• Production of ion beams for therapy
• Ion beam application: principles of beam scanning
• Ion beam monitors and detectors
• Dose calculation and treatment planning
• Image guidance
• Irradiation of moving organs
• Monitoring of beam application and range in the patient
This lectures handles both the user perspective as well as technical realization of real-time beam control and algorithms in treatment planning and application. Theoretical foundations will be accompanied by practical exercises, where students will learn to use public domain software for treatment planning for different applications in ion beam therapy and research.</td></tr>
<tr><td>2</td><td>Learning objectives
After successful completion of the module, students know the physical and radiobiological properties of ion beams that justify their use in cancer therapy. They can describe existing clinical facilities and understand their accelerators for ion beam production. The students learned methods to apply ion beams to patients, in particular beam scanning, including hardware and algorithms used in real-time therapy control. Using the program matrad, they can conduct basic treatment planning, evaluate treatment plans and judge their robustness in application. The students know advantages and challenges of ion beam therapy as well as strategies addressing relevant sources of uncertainty in their application.</td></tr>
<tr><td>3</td><td>Recommended prerequisites for participation
Radiation sources in Medicine</td></tr>
<tr><td>4</td><td>Form of examination
Module exam:
• Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS)
The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 20 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</td></tr>
<tr><td>5</td><td>Prerequisite for the award of credit points
Passing the final module examination</td></tr>
<tr><td>6</td><td>Grading
Module exam:
• Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td>Usability of the module
M.Sc. MedTec</td></tr>
</table>

8	**Grade bonus compliant to §25 (2)**
9	**References** • Schardt et al. ‘ Heavy-ion tumor therapy: Physical and radiobiological benefits', 2010; DOI: 10.1103/RevModPhys.82.383 • NuPECC: ‘ Nuclear Physics for Medicine', 2014, www.nupecc.org/pub/npmed2014.pdf

Courses

Course nr.	Course name	Instructor	Type	SWS
18-gr-2020-vl	Ion Beam Therapy	Prof. Dr.-Ing. Christian Graeff	Lecture	2
18-gr-2020-ue	Ion Beam Therapy	Prof. Dr.-Ing. Christian Graeff	Practice	1

Module name					
Advanced Power Electronics					
Module nr. 18-gt-2010	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1 Teaching content

Switch mode power supplies (insulating DC/DC-converters) Realistic behavior of power semiconductors: Basics of semiconductor physics; Behavior of diode, bipolar transistor, SCR, GTO, MOSDFET and IGBT, Important circuits for switching real semiconductors with low losses
Thermal design and thermo mechanical aging of power electronics systems
Reliability of Power electronic systems
Forced commutation of SCRs, Loss reducing snubbers, quasi- resonant circuits, resonant switching.
Topologies and control strategies for multilevel converter

2 Learning objectives

Upon successful completion of the module, students will be able to:

1. Explain und understand the cross sectional layers and the basic modes of operation for power semiconductors (diode, thyristor, GTO. Mosfet and IGBT). Describe the steady state and dynamic behavior of these devices.
2. Identify the circuit diagrams for isolating DC/DC converters, especially for use in switched mode power supplies. Calculate the currents and voltages in these circuits using defined simplifications.
3. Describe the functions of gate dive-circuits for ITGBTs.
4. Calculate the thermal behavior and design the cooling equipment for a voltage source inverter equipped with IGBT modules.
5. Describe the stress reliving circuits to reduce switching losses in IGBTs.
6. Calculate the current and voltage characteristics in quasi-resonant and resonant circuits used in power electronics.
7. Explain multilevel converters such as 3L-NPC and MMC
8. Know the main concepts for cooling of power electronics incl. the ability to design a cooling concept and should know main aspects which influence lifetime

3 Recommended prerequisites for participation

BSc ETiT or equivalent, especially Power Electronics and Basics of Semiconductors

4 Form of examination

Module exam:

- Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

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

7 Usability of the module

M.Sc. MEC, M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

Script available in Moodle for download
Literature:

- Schröder, D.: “Leistungselektronische Schaltungen”, Springer-Verlag, 1997
- Mohan, Undeland, Robbins: Power Electronics: Converters, Applications and Design; John Wiley Verlag; New York; 2003
- Luo, Ye: “Power Electronics, Advanced Conversion Technologies”, Taylor and Francis, 2010

Courses

Course nr.	**Course name**		
18-gt-2010-vl	Advanced Power Electronics		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Gerd Griepentrog		Lecture	2
Course nr.	**Course name**		
18-gt-2010-ue	Advanced Power Electronics		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Gerd Griepentrog		Practice	2

Module name Control of Drives					
Module nr. 18-gt-2020	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1 Teaching content

Control structures for drives; Design of controllers for drives; VSIs for drives; Space Vectors as basis of modelling AC-machines; Reference frames for description of AC-machines; Control oriented block diagram for DC-drive; Structure and design of the controllers;
Control oriented block diagram for Permanent Magnet Synchronous Machine (PMSM); Control oriented block diagram for Induction machine (IM)
Torque control for AC-machines using linear or switching controllers. Field Oriented Control and Direct Torque Control for PMSM and IM. Models and observers for rotor flux of IM
Speed control, including oscillatory load. Resolver and Encoder. Problem of Motion control

2 Learning objectives

Upon successful completion of the module, students will be able to:

1. develop the control-oriented block diagrams for the DC-machine operating in base speed range as well as in field weakening range.
2. design the control loops for 1.) concerning the structure and the control parameters.
3. Understand and apply space vectors and master their application in different rotating frames of reference.
4. Develop the dynamic equations of the permanent exited synchronous machine and the induction machine and to simplify these equations by help of suitable rotating reference frames and represent these equations as non-linear control-oriented block diagram.
5. Design the control loops according to 4.) especially the field-oriented control concerning the structure of the control loops and the control parameters.
6. Understand the deduction of equations given in the literature for machine types, which are not discussed in this lecture, e.g. for the doubly fed induction machine.
7. Derive the models and the observers for the rotor flux for the induction machine in different frames of reference and to apprise the benefits and drawbacks of the different solutions.
8. Design the control loops for the super-imposed speed controls even for mechanically oscillating loads.

3 Recommended prerequisites for participation

BSc ETiT or equivalent, especially Control Theory and Electrical Machines / Drives

4 Form of examination

Module exam:
- Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

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

7 Usability of the module

M.Sc. MEC, M.Sc. ESE, M.Sc. etit - SAE, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9	**References** Lecture notes, instructions for exercises are available in Moodle for download. Literature: • Mohan, Ned: "Electric Drives and Machines" • De Doncker, Rik; et. al.: "Advanced Electrical Drives" • Schröder, Dierk: "Elektrische Antriebe - Regelung von Antriebssystemen" • Leonhard, W.: "Control of Electrical Drives"

Courses

Course nr.	Course name	Instructor	Type	SWS
18-gt-2020-vl	Control of Drives	Prof. Dr.-Ing. Gerd Griepentrog	Lecture	2
18-gt-2020-ue	Control of Drives	M.Sc. Ivan Kliasheu, Prof. Dr.-Ing. Gerd Griepentrog	Practice	2

Module name Real Time Applications and Communication with Microcontrollers and Programmable Logic Devices					
Module nr. 18-gt-2040	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1 Teaching content

Microcontroller and programmable logic devices are being used for a variety of control tasks for industrial and residential products and systems. For the control of drives and power electronics, those devices are used for the control of frequency converters or DC/DC converters.
In most of these applications, real time requirements have to be met. Simultaneously a communication interface has to be served.
The module will impart knowledge and expertise on how to realize successfully control task.
More in detail, the following content will be taught:

- Architecture of microcontroller
- Structure and function of FPGAs, tools and programming languages
- Typical peripheral components for microcontrollers
- Capture & Compare, PWM, A/D-converter
- I2C, SPI, CAN, Ethernet
- Programming of microcontrollers in C
- Software: real-time properties, interrupt handling, interrupt latency
- Control of inductive components
- Basic of circuit design for power electronics, Power-MOSFETS, IGBTsNumerical methods

2 Learning objectives

Students will be able to:

- Separate a digital control task into HW and SW parts
- Specify the HW-content in a HW description language and implement the SW by means of a microcontroller
- Evaluate the real-time capabilities of a program and to determine upper limits for the response time of the systemTransfer the developed solution to the target system by means of a development kit and debug the software onto the target system.

3 Recommended prerequisites for participation

Basic knowledge in programmig language C (syntax, operators, pointer)

4 Form of examination

Module exam:

- Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

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

7 Usability of the module

M.Sc. MEC, M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

	Script, Instruction for practical lab courses, ppt-Slides; either in hard-copy or for download; User Manuals of the used devices and development kits

Courses

Course nr.	Course name		
18-gt-2040-vl	Real Time Applications and Communication with Microcontrollers and programmable Logic Devices		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Gerd Griepentrog		Lecture	1

Course nr.	Course name		
18-gt-2040-pr	Real Time Applications and Communication with Microcontrollers and programmable Logic Devices		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger, Prof. Dr.-Ing. Gerd Griepentrog		Lab	2

Module name					
Artificial Intelligence in Medicine					
Module nr. 18-ha-2020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Christoph Hoog Antink		

1	**Teaching content**
	
	• Introduction, terms and delimitations
	• Data acquisition and preprocessing
	• Feature extraction and visualization methods
	• Statistical fundamentals
	• Classification methods
	    – Linear Regression, Logistic Regression
	    – Support Vector Machines
	    – Decision Trees, Random Forest, XGBoost
	    – Neural Networks
	• Overfitting and underfitting with medical data
	• Influence of unbalanced data sets
	• Evaluation of algorithms
	• "Explainable AI"
	• Regulatory Requirements

2	**Learning objectives** Students have a basic understanding of the terminology of Artificial Intelligence, especially in the medical context. They have learned how features can be extracted from medical data and visualized. The students have an overview of current procedures and know how they work. They are familiar with current application examples from various subfields of medical technology, e.g. signal processing, image processing, spectroscopy, gene sequencing, etc. Students understand the dangers of underfitting, overfitting, and imbalanced (e.g. related to gender ratio) data sets in a medical context. They are aware of the social and ethical responsibility of their future professional activities in relation to Fair AI. Students have an advanced understanding of algorithm evaluation, are familiar with the concept of ”Explainable AI” and know the basic regulatory requirements for medical software. They are able to independently develop AI-based solutions to medical technology problems.
3	**Recommended prerequisites for participation** 18-zo-1030 Fundamentals of Signal Processing
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 21 students register, the examination will be an oral examination (duration: 20 min.).
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**

By participating in online tests, a bonus can be acquired for the exam. The following key applies "points achieved at the end of the semester" –> "grade improvement": 60% –> 0.1; 65% –> 0.2; 70% –> 0.3; 75% –> 0.4; >=80% –> 0.5. The bonus is converted into raw points, i.e. a bonus of 0.5 corresponds to half the points of a whole grade step (e.g. 3.0 to 2.0). Exam Bmust be passed without a bonus to receive the bonus. The total score is the points achieved + bonus points and is rounded."

9 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.	Course name	Instructor	Type	SWS
18-ha-2020-vl	Artificial Intelligence in Medicine	Prof. Dr.-Ing. Christoph Hoog Antink	Lecture	2
18-ha-2020-ue	Artificial Intelligence in Medicine	Prof. Dr.-Ing. Christoph Hoog Antink	Practice	1
18-ha-2020-pr	Artificial Intelligence in Medicine	Prof. Dr.-Ing. Christoph Hoog Antink	Lab	1

Module name Low-Level Synthesis					
Module nr. 18-hb-2010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Christian Hochberger		

1	**Teaching content** The module deals with synthesis steps on all abstraction layers below the register transfer level focusing on approaches suitable for FPGAs. At the logic level different types of minimization are explained (exact and heuristic two level minimizations, exact and heuristic multi level logic minimizations). The transition to the technology level is achieved by different decomposition and structural mapping techniques (FlowMap). Place&Route add geometric information to the technology mapped circuit. Analytical and heuristic placers are discussed (Simulated Annealing, Genetic Placers) and routing is illustrated through the PathFinder algorithm.
2	**Learning objectives** After completion of the module, students are enabled to investigate synthesis approaches for low level synthesis tasks. They can evaluate these approaches regarding their time and space complexity, as well as regarding their applicability to specific implementation technologies. Students can apply these approaches to new architectures and technologies.
3	**Recommended prerequisites for participation** Knowledge of hardware synthesis on the basis of at least one hardware description language is required (e.g. Reese/Thornton: Introduction to Logic Synthesis Using Verilog Hdl oder Brown/Vranesic: Fundamentals of Digital Logic with VHDL Design). The student should have basic knowledge of at least one object oriented programming language, preferably Java.
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. iCE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** The slides of the lecture will be distributed through moodle.

Courses

Course nr.	**Course name**		
18-hb-2010-vl	Low-Level Synthesis		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Lecture	2

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<tr><td rowspan="2"></td><td>Course nr.
18-hb-2010-pr</td><td colspan="3">Course name
Low-Level Synthesis</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Christian Hochberger</td><td>Type
Lab</td><td>SWS
2</td></tr>
</table>

Module name
High-Level Synthesis

Module nr.	Credit points	Workload	Self-study	Module duration	Module cycle
18-hb-2020	6 CP	180 h	120 h	1 Term	Winter term

Language	Module owner
English	Prof. Dr.-Ing. Christian Hochberger

1 Teaching content
Mapping of behavioral descriptions (e.g. in the form of program fragments) on FPGA and CGRA structures
- Sub-tasks allocation, scheduling, binding
- Exact or heuristic solutions
- Design principles of heuristic solutions

2 Learning objectives
Students that have completed this module know alternative approaches for all of the tasks of the high level synthesis and can select appropriate ones for specific applications. They can evaluate the memory and time complexity of the given algorithms. They are enabled to adapt the algorithms for new constraints and new target technologies.

3 Recommended prerequisites for participation
Knowledge of hardware synthesis on the basis of at least one hardware description language is required (e.g. Reese/Thornton: Introduction to Logic Synthesis Using Verilog Hdl oder Brown/Vranesic: Fundamentals of Digital Logic with VHDL Design). The student should have basic knowledge of at least one object oriented programming language, preferably Java

4 Form of examination
Module exam:
- Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)

5 Prerequisite for the award of credit points
Passing the final module examination

6 Grading
Module exam:
- Module exam (Technical examination, Oral examination, Weighting: 100 %)

7 Usability of the module
M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. iCE, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References
English slides can be obtained through Moodle.

Courses

Course nr.	Course name	Instructor	Type	SWS
18-hb-2020-vl	High-Level Synthesis	Prof. Dr.-Ing. Christian Hochberger	Lecture	2
18-hb-2020-pr	High-Level Synthesis	Prof. Dr.-Ing. Christian Hochberger	Lab	2

Module name Computer Systems II					
Module nr. 18-hb-2030	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Christian Hochberger		

1	**Teaching content** • Configurable Technologies • FPGA architectures and properties • System-On-Chip, HW components, SW toolchain, support SW • Coarse grained reconfigurable architectures, PE architecture, Modulo schedu-ling
2	**Learning objectives** After completion of the module, students know reconfigurable technologies as well as chip architecture that employ them (e.g. FPGAs and CGRAs). They can select an ap-propriate technology for a given specific application. They know the components a system-on-chip (SoC) consists of. Students can configure and program an application specific SoC. They can map simple applications to a CGRA and know the limitations and pitfalls of this mapping.
3	**Recommended prerequisites for participation** Thorough basic knowledge of digital circuits and computer achitecture. as can be ob-tained in the lectures “Logischer Entwurf” and “Rechnersysteme I”. Additionally, stu-dents should be able to write simple programs in the programming language C.
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - DT, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. iCE, M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** The slides (in German) of the lecture can be obtained through moodle.

Courses

Course nr.	Course name		
18-hb-2030-vl	Computer Systems II		
Instructor		**Type**	**SWS**
M.Sc. Ramon Wirsch, Prof. Dr.-Ing. Christian Hochberger		Lecture	3

Course nr.	Course name		
18-hb-2030-ue	Computer Systems II		
Instructor		**Type**	**SWS**
M.Sc. Ramon Wirsch, Prof. Dr.-Ing. Christian Hochberger		Practice	1

Module name					
Advanced Digital Integrated Circuit Design					
Module nr. 18-ho-2010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1 Teaching content

MOS Transistor Models, CMOS Logic Gates, Chip Layout and Design Rules, Static and Dynamic Behavior of CMOS Circuits, Synchonous CMOS Circuits, Performance and Power Characterisation, Design Techniques and CAD Tools, FPGA and Gate Array Technologies, Memory Technologies, Data-Converters (A/D, D/A), Chip Test.

2 Learning objectives

A student is, after successful completion of this module, able to
- understand the short-channel effects of modern CMOS transistors,
- derive and analyse the most important circuit concepts for digital logic gates,
- understand the design flow of digital ASICs based on standard cells (design, layout, simulation/verification),
- know the pros and cons of synchronous vs. asynchronous logic, multiclockphase systems,
- understand the differential design methods of integrated circuits (ASIC, ASIP, Full-custom/Semicustom, PLA, PLD, FPGA),
- understand basic circuitry of logic and arithmetic units (adders, multipliers, PLL/DLL),
- understand the concepts of A/D and D/A-converters, and their fundamental technical properties and architectures,
- know the design principles and properties of integrated semiconductor memory (DRAM, SRAM, Flash. MRAM, FeRAM)

3 Recommended prerequisites for participation

Lecture "Electronics"

4 Form of examination

Module exam:
- Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

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

7 Usability of the module

M.Sc. etit - DT, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. iCE, M.Sc. iST

8 Grade bonus compliant to §25 (2)

A grade improvement of up to 1,0 due to a bonus is possible, which can be earned with tests.

9 References

Lecture Slide Copies
- John P. Uyemura: Fundamentals of MOS Digital Integrated Circuits
- Neil Weste et al.: Principles of CMOS VLSI Design

Courses

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-ho-2010-vl</td><td colspan="3">Course name
Advanced Digital Integrated Circuit Design</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Klaus Hofmann</td><td>Type
Lecture</td><td>SWS
3</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-ho-2010-ue</td><td colspan="3">Course name
Advanced Digital Integrated Circuit Design</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Klaus Hofmann</td><td>Type
Practice</td><td>SWS
1</td></tr>
</table>

Module name Microprocessor Systems					
Module nr. 18-ho-2040	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1 Teaching content

Microprocessor Architectures, DSP Architectures and Hardware related Programming

2 Learning objectives

Upon successful completion of the module, students will be able to:

1. gain the overview on the fundamentals of computer architecture and the different processor classes (RISC, CISC, Mikrocontroller, CPU, DSP),
2. understand the central building blocks of a CPU
3. understand the major properties of the required semiconductor memories, I/O blocks and data busses (USB, PCI, RS232),
4. understand the most commonly used Interrupt- and Trap-handling algorithms,
5. know the common software development methodologies for microcontrollers (assembler, pseudooperations, makros, subprograms and subroutines),
6. understand the most important fundamentals of hardware oriented programming using C.

3 Recommended prerequisites for participation

Basics of Computer Architectures

4 Form of examination

Module exam:

- Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

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

7 Usability of the module

M.Sc. MEC, M.Sc. etit - DT, M.Sc. iCE, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

During the semester, a maximum grade improvement of 1.0 can be achieved. The grade improvement has no influence on passing the final module examination. Bonus points are awarded for the successful completion of tests. The points achieved in the bonus system are converted linearly into exam points, with 50% of the achievable bonus points 0 exam points are added accordingly, from 95% of the achievable bonus points exam points are added for a grade improvement of 1.0. Bonus points are scored from a maximum of three tests, each of which must be on a different topic. Several tests can be offered for each topic; tests can also be offered for more than three topics. The exact bonus system will be presented at the beginning of the course. The aim of the bonus system is to be able to test the programming of microcontrollers in a more practical way.

9 References

Slide Copies

Courses

	Course nr. 18-ho-2040-vl	**Course name** Microprocessor Systems		
	Instructor M.Sc. Dirk Leiacker, Dr.-Ing. Matthias Rychetsky		**Type** Lecture	**SWS** 2
	Course nr. 18-ho-2040-ue	**Course name** Microprocessor Systems		
	Instructor M.Sc. Dirk Leiacker, Dr.-Ing. Matthias Rychetsky		**Type** Practice	**SWS** 1

Module name Computer Aided Design for SoCs					
Module nr. 18-ho-2200	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Teaching content** CAD-Concepts for the design and simulation of integrated system-on-chips
2	**Learning objectives** A student is, after successful completion of this module, able to understand • the most important design and verification abstractions as well as the design flow for the design of integrated electronic systems, • selected algorithms for optimization, simulation and solving of design tasks, • advanced methods for the design and simulation of analog integrated circuits in modern CMOS technologies, • advanced concepts of hardware description languages and their concepts (Verilog, VHDL, Verilog-A, Verilog-AMS, System-Verilog)
3	**Recommended prerequisites for participation** Lecture "Advanced Digital Integrated Circuit Design" (can be attended in parallel) and „Electronic and Integrated Circuits" and "Logic Design"
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - DT, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. iCE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)** A grade improvement of up to 1,0 due to a bonus is possible, which can be earned by successful participation in the embedded labs.
9	**References** Slide Copies

Courses

Course nr.	Course name	Instructor	Type	SWS
18-ho-2200-vl	Computer Aided Design for SoCs	Prof. Dr.-Ing. Klaus Hofmann	Lecture	2
18-ho-2200-ue	Computer Aided Design for SoCs	Prof. Dr.-Ing. Klaus Hofmann	Practice	1

	Course nr.	Course name		
	18-ho-2200-pr	Computer Aided Design for SoCs		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Klaus Hofmann		Lab	1

Module name Industrial Electronics					
Module nr. 18-ho-2210	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1 Teaching content

Typical Struture of Industrial Electronics Components. Characteristics of Typical Building Blocks (Digital Core, Sensor Frontend, Actuator Frontend, Supply and Reference Level), Functioning of Relevant Field Bus Systems, Knowledge of Relevant Standards and Technical Regulations.

2 Learning objectives

After successfull completion of the module, students are able to:

1. understand the use of electronic components in typical industrial environments,
2. understand the function of the building blocks of typical IE comonents,
3. deeply understand the functioning of analog bulding blocks,
4. understand relevant field bus systemes,
5. understand the regulatory and technical standards of industrial electronics components.

3 Recommended prerequisites for participation

Lecture "Elektronik" and "Electronic and Integrated Circuits"

4 Form of examination

Module exam:
- Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)

The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 5 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 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. MEC, M.Sc. etit - DT, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. etit - AUT, M.Sc. iCE, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

- Dietmar Schmid, Gregor Häberle, Bernd Schiemann, Werner Philipp, Bernhard Grimm, Günther Buchholz, Jörg Oestreich, Oliver Gomber, Albrecht Schilling: „Fachkunde Industrieelektronik und Informationstechnik“; Verlag Europa-Lehrmittel, 11 th Ed. 2013.
- Gunter Wellenreuther, Dieter Zastrow; „Automatisieren mit SPS - Theorie und Praxis“; Springer Verlag, 6 th Ed. 2015.
- Ulrich Tietze, Christoph Schenk, Eberhard Gamm: „Halbleiter-Schaltungstechnik“; Springer Verlag, 15 th Ed. 2016.

Courses

	Course nr. 18-ho-2210-vl	**Course name** Industrieelektronik		
	Instructor Dr.-Ing. Roland Steck		**Type** Lecture	**SWS** 2
	Course nr. 18-ho-2210-ue	**Course name** Industrieelektronik		
	Instructor Dr.-Ing. Roland Steck		**Type** Practice	**SWS** 1

Module name Regulation and Operation of Power Supply					
Module nr. 18-hs-2010	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1 Teaching content

- Basic introduction to the regulation of distribution systems operators. In this context, different tasks of the grids with regard to the energy supply as well as the „Energiewende“ will be addressed.
- Technical functions for the operation of grid supply. Functions here are asset management, system operations and metering.
- Excursion with on-site visit (grid control center, current project or power plants)
- Non-technical functions related to the operation of grid supply. These include regulatory functions such as connection management and billing, occupational safety and management of critical infrastructure.
- Incentive regulation as a regulatory framework for utility network operation
- Insights into entrepreneurial tasks and field reports

2 Learning objectives

After attending the module, students will be familiar with the basic technical and non-technical functions of distribution systems operators. After a basic introduction, the course first teaches the technical tasks for the operation of supply networks. Topics here are asset management, grid operation, and metering. In the second part, the non-technical functions are taught. Here, the connection management, the occupational safety, the environmental and health protection as well as the crisis management in distribution networks play a central role. The module also provides a basic understanding of the driving factors and developments in (German) power grids with regard to the “Energiewende”. In addition, students will also be familiar with the different levels of incentive regulation, from operating resources to grid charges. Last but not least, the module provides students with targeted insights into entrepreneurial tasks and field reports from practice.

3 Recommended prerequisites for participation

Good knowledge of content of the lecture "Energietechnik"

4 Form of examination

Module exam:
- Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

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

7 Usability of the module

M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

9 References

A lecture notes or slides can be downloaded:

- Moodle Platform

Additional literature:

- To be announced at the beginning of the lecture

Courses

Course nr.	**Course name**		
18-hs-2010-vl	Regulation and Operation of Power Supply		
Instructor		**Type**	**SWS**
M.Sc. Felix Korff, Dr.-Ing. Andreas Berg, M.Sc. Marcel Böhringer		Lecture	2

Module name					
Elektrische Energieversorgung II / Power Systems II					
Module nr. 18-hs-2030	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1	**Teaching content** The lecture Power Supply II deals with the dynamic behavior of electrical power systems. For this the stationary behavior of the equipment is extended by the dynamic behavior, in order to show the resulting network behavior. With this background in-depth insights into the stability of the electrical power supply network are provided. The influence of controlled generation plants on stability is addressed. Finally, power quality is considered, which is gaining importance for steady-state and dynamic behavior with the increased use of power electronics. The following topics will be covered: • Steady-state and dynamic behavior of synchronous generators and renewable generation plants (grid behavior and control of power electronic converters) • Time curve of short-circuit currents and their quasi-stationary calculation • Stability types (static stability, transient stability, voltage stability, frequency stability, resonance stability & inverter-driven stability) • Power quality
2	**Learning objectives** After successful completion of the module, the students have a profound understanding of the different types of stability of electrical power systems. They have gained a basic understanding of dynamic network behavior and the control of generation plants, as well as power quality.
3	**Recommended prerequisites for participation** Knowledge comparable to "Energieversorgung I" or basic knowledge of power system equipment and calculations using symmetrical components.
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture slides, tutorials and past exams are available via Moodle.

Courses

Course nr.	Course name		
18-hs-2030-vl	Elektrische Energieversorgung II / Power Systems II		
Instructor		**Type**	**SWS**
M.Sc. Anna Pfendler, Prof. Dr.-Ing. Jutta Hanson, M.Sc. Soham Choudhury		Lecture	2

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-hs-2030-ue</td><td colspan="3">Course name
Elektrische Energieversorgung II / Power Systems II</td></tr>
<tr><td colspan="2">Instructor
M.Sc. Anna Pfendler, Prof. Dr.-Ing. Jutta Hanson, M.Sc. Soham Choudhury</td><td>Type
Practice</td><td>SWS
2</td></tr>
</table>

Module name Elektrische Energieversorgung III / Power Systems III					
Module nr. 18-hs-2080	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1	**Teaching content** This lecture covers the power transmission and system analysis of transmission systems and the innovative system equipment. The following topics will be covered: • Power flow analysis (network theory, power flow calculation) • Power system stability (rotor angle stability, voltage stability, frequency stability, etc.) • Power system regulation (operating reserve, primary reserve, secondary reserve, tertiary reserve) • Power transmission and ancillary services • Compensation, Power flow control • Power electronics (LCC-HVDC, VSC-HVDC) • Flexible AC Transmission Systems (FACTS) • Practical examples and outlook
2	**Learning objectives** After successful completion of this module, the students have a profound understanding of the power system stability and analysis, know the driving forces for the utilisation of innovative equipment (HVDC,FACTS) in power systems. They understand the system behaviour and operation of this equipment and can model it and thus design it for safe and reliable operation.
3	**Recommended prerequisites for participation** Contents of “Power Systems I” and “Power Systems II”
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes the form of a written examination (duration: 90 minutes). If it is foreseeable that fewer than 6 students will register, the examination will be oral (duration: 30 minutes). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE
8	**Grade bonus compliant to §25 (2)** Yes
9	**References** Lecture slides, exercises and past exams are available via Moodle

Courses

Course nr.	**Course name**		
18-hs-2080-vl	Elektrische Energieversorgung III / Power Systems III		
Instructor M.Sc. Siyuan Li, Prof. Dr.-Ing. Jutta Hanson		**Type** Lecture	**SWS** 2

Module name					
Power Plants and Renewable Energies					
Module nr.	**Credit points**	**Workload**	**Self-study**	**Module duration**	**Module cycle**
18-hs-2090	4 CP	120 h	75 h	1 Term	Winter term
Language			**Module owner**		
German			Prof. Dr.-Ing. Jutta Hanson		

1 Teaching content

Forms of energy, Characteristics and figures of electricity industry, Importance of power generation - Energy Conversion in thermal processes (Carnot-Process), Categorization of power plants - Operation principle of steam power plants, gas power plants, water power plants, wind power plants, Use of solar energy (Photovoltaics, Solar thermal technology) and further regenerative energy sources (geothermal energy, biomass) - Technologies for Energy Converting and Storing (Power 2 X) - Electrical systems - Grid Connection for power plants

2 Learning objectives

On completion of the module students were taught the following:
- Overview of concepts of power generation by various energy sources
- Comprehension of physical processes
- Operation principle and design of conventional and renewable power plants and storage
- Comprehension of electrical devices and control concepts

3 Recommended prerequisites for participation

Basics in Electrical Engineering, Power Engineering

4 Form of examination

Module exam:
- Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

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

7 Usability of the module

M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

9 References

Script

Courses

Course nr.	Course name	
18-hs-2090-vl	Power Plants and Renewable Energies	
Instructor	**Type**	**SWS**
M.Sc. Aaron Hebing, Prof. Dr.-Ing. Jutta Hanson, M.Sc. Xiong Xiao, M.Sc. Manuel Schwenke	Lecture	2

	Course nr. 18-hs-2090-ue	**Course name** Power Plants and Renewable Energies		
	Instructor M.Sc. Aaron Hebing, Prof. Dr.-Ing. Jutta Hanson, M.Sc. Xiong Xiao, M.Sc. Manuel Schwenke		**Type** Practice	**SWS** 1

Module name Power System Protection					
Module nr. 18-hs-2120	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner**		

1	**Teaching content** Neutral point earthing Protection types in power systems • Over-current protection • Current differential protection • Distance protection • Earth fault protection • Further types of protection Hardware implementation: • Protection relays (design + testing) • Instrument transformers Application of the protection types in protection concepts for • Power system operators • Industry • Wind and solar parks Influence of the energy transition on neutral point earthing and power system protection
2	**Learning objectives** After successful completion of this module, the students understand the influence of neutral point earthing on power system protection and know the different protection types in power systems. They have on overview of their hardware implementation and understand the application and interaction of the different protection types in protection concepts.
3	**Recommended prerequisites for participation** Contents of "Power Systems I"
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 6 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	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References** Presentation slides
Courses	

	Course nr.	Course name		
	18-hs-2120-vl	Power System Protection		
	Instructor		**Type** Lecture	**SWS** 2

Module name MIMO - Communication and Space-Time-Coding					
Module nr. 18-ja-2010	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Vahid Kooshkghazi		

1	**Teaching content** This lecture course introduces the principles of space-time and multiple-input multiple-output (MIMO) communications. Outline: Motivation and background; overview of space-time and MIMO communications; fading MIMO channel models, MIMO information theory, receive and transmit diversity; channel estimation, MIMO detectors, Alamouti space-time block code, orthogonal space-time block codes; linear dispersion codes; coherent and non-coherent decoders, differential space-time block coding; MIMO with limited feedback, Multiantenna- and multiuser diversity, BER performance analysis, MIMO in moden wireless communication networks, multicell and multiuser MIMO (coordinated multipoint).
2	**Learning objectives** Students will understand modern MIMO communications and existing space-time coding techniques.
3	**Recommended prerequisites for participation** Knowledge of basic communication theory and basic information theory.
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS) The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 10 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. WI-etit, M.Sc. etit - KTS, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**References** • A.B.Gershman and N.D.Sidiropoulos, Editors, Space-Time Processing for MIMO Communications, Wiley and Sons, 2005. • E.G.Larsson and P.Stoica, Space-Time Block Coding for Wireless Communications, Cambridge University Press, 2003; • A.Paulraj, R.Nabar, and D.Gore, Introduction to Space-Time Wireless Communications, Cambridge University Press, 2003. • Lin Bai and Jinho Choi, Low Complexity MIMO detectors, Springer, 2012. • Howard Huang, Constantinos B. Papadias, and Sivarama Venkatesan, MIMO Communication for Cellular Networks, Springer, 2012.
Courses	

	Course nr. 18-ja-2010-vl	**Course name** MIMO - Communication and Space-Time-Coding		
	Instructor Prof. Dr.-Ing. Vahid Kooshkghazi		**Type** Lecture	**SWS** 2
	Course nr. 18-ja-2010-ue	**Course name** MIMO - Communication and Space-Time-Coding		
	Instructor Prof. Dr.-Ing. Vahid Kooshkghazi		**Type** Practice	**SWS** 1

Module name Synthetic Molecular Communication					
Module nr. 18-ja-2020	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Vahid Kooshkghazi		

1	**Teaching content** This lecture course introduces the basic principles in modeling, design, and analysis of synthetic molecular communication (MC) systems. The course covers the following topics: • Basic principles of synthetic MC systems and potential application scenarios • Background concepts from biology and chemistry needed to understand MCs • Mathematical modeling of MC channels involving advection-reaction-diffusion processes • Design of modulation and detection schemes for synthetic MC systems • Channel estimation and parameter estimation for synthetic MC systems • Review of several experimental MC systems, their practical implementation considerations, and the signal processing of the measurement data
2	**Learning objectives** After completion of this interdisciplinary lecture, students will be able to • explain the basic principles of MCs and differentiate them with respect to conventional electromagnetic-based communications • explain basic related concepts from chemistry and biology such as chemical reactions, molecules, proteins, communication within and between cells, etc. • apply the relevant physical/chemical laws (e.g., Fick's law or in general advection-reaction-diffusion equations) to derive communication-theoretical models for MC channels • name several modulation schemes for embedding information into the properties of molecules and derive optimal and suboptimal detection for recovering information • derive estimators for estimating the MC channel impulse response or physical parameters of the MC channel • name several state-of-the-art implementations of synthetic MCs and explain the features/limitations/challenges of building MC systems, in practice The students will deepen their knowledge of the fundamentals of communication systems by reflecting on and "re-learning" the entire communication blocks (e.g., modulation, detection, estimation, etc.) in the new context of MCs
3	**Recommended prerequisites for participation** Knowledge of basic communication theory and digital communication
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS) The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 10 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. etit - KTS, M.Sc. MedTec, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS

<table>
<tr><td>8</td><td colspan="4">Grade bonus compliant to §25 (2)
Grade improvements up to 0.4 according to APB 25(2) through bonus for regularly completed and submitted bonus exercises</td></tr>
<tr><td>9</td><td colspan="4">References
A lecture notes or slides can be downloaded:
Moodle Platform
Supplementary and advanced literature:
T. Nakano, A. Eckford, and T. Haraguchi. Molecular Communications, Cambridge University Press, 2013
T. Nakano, A. Eckford, and T. Haraguchi. Molecular Communications, Cambridge University Press, 2013
P. Nelson. Biological Physics - Energy, Information, Life, Freeman and Company, 2004.</td></tr>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-ja-2020-vl</td><td colspan="3">Course name
Synthetic Molecular Communication</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Vahid Kooshkghazi</td><td>Type
Lecture</td><td>SWS
2</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-ja-2020-ue</td><td colspan="3">Course name
Synthetic Molecular Communication</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Vahid Kooshkghazi</td><td>Type
Practice</td><td>SWS
1</td></tr>
</table>

Module name Antennas and Adaptive Beamforming					
Module nr. 18-jk-2020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1	**Teaching content** Overview of most important antenna parameters types as well as their applications. Fundamental theories: Fourier transform for far-field pattern calculations, antenna modeling techniques, antenna synthesis methods, image theory, determination of field regions of line sources, of the average radiated power density and power, directivity and gain. Antennas as key elements in power budgets of radio links, introducing the effective aperture of an antenna, deriving the relation between gain and effective aperture. Array antennas are a key hardware for beamforming and smart antenna systems: fundamentals of phased-scanning arrays, non-uniformly excited, equally spaced linear arrays, multi-dimensional planar arrays and mutual coupling effects. Wire antennas: still the most prevalent of all antenna forms, relatively simple in concept, easy to construct, very inexpensive. Antenna radiation fields and antenna parameters for different types of antennas are derived from Maxwell´s equations, applied for aperture antennas (horns, lenses or reflector antennas) and printed antennas (microstrip-patch and coplanar-slot antennas) Some basic numerical calculation methods: integral equation methods in the time and frequency domain, physical optics and uniform theory of diffraction are briefly summarized and compared for antennas and scattering problems. Smart antennas in communication and radar systems, with focus on beam steering and adaptive beamforming.
2	**Learning objectives** Students will know basic antenna parameters: pattern, gain, directivity, half-power beamwidth, side- lobe-level, efficiency and input impedance to compare, assess and evaluate different antennas for various applications and operating frequencies. The antenna field regions, reactive near-field, near-field and far-field, can be differentiated and the far-field pattern of an antenna can be determined from given current distributions along the antenna by using Fourier transformation or integral solutions with distributed ideal dipoles as basic elements (antenna analysis). To assess in general physical requirements, constrains and limitations of antennas, students can use fundamental antenna theory: impedance matching techniques, antenna modeling and far-field pattern analysis, antenna synthesis, image theory and fundamental limits of electrically small antennas. After being incorporated into the different adaptive beamforming techniques, the array theory enables the student to design antenna systems that are assembled of a certain number of separate elements, feeding network, beamforming network etc. for phased-scanning or smart antennas in communications and sensing. Moreover, students are able to determine, analyze and evaluate the most important classes of antennas in wireless technology for many applications, operating frequencies, desired requirements or practical constrains: (1.) wire- dipole antennas, (2.) planar antennas (microstrip, dipole and slot antennas), (3.) aperture antennas (horn antennas, parabolic reflector antennas, lens antennas, Cassegrain and Gregorian double-reflector configurations), (4.) broadband and frequency-independent antennas (V antennas, biconical antennas, helical antennas, spiral and log-periodic antennas).
3	**Recommended prerequisites for participation** Fundamentals of Communications, Microwave Engineering 1
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading**

	Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. iCE, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Skriptum "Antennas and Adaptive Beamforming" will be provided electronically at the beginning of the lecture.

Courses

Course nr.	Course name		
18-jk-2020-vl	Antennas and Adaptive Beamforming		
Instructor		**Type**	**SWS**
Dr.-Ing. Martin Schüßler, Dr.-Ing. Alejandro Sáez, M.Sc. Jesús Pastor		Lecture	3
Course nr.	**Course name**		
18-jk-2020-ue	Antennas and Adaptive Beamforming		
Instructor		**Type**	**SWS**
Dr.-Ing. Martin Schüßler, Dr.-Ing. Alejandro Sáez, M.Sc. Jesús Pastor		Practice	1

<table>
<tr><td colspan="6">Module name
Radar Techniques</td></tr>
<tr><td>Module nr.
18-jk-2040</td><td>Credit points
3 CP</td><td>Workload
90 h</td><td>Self-study
60 h</td><td>Module duration
1 Term</td><td>Module cycle
Winter term</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr.-Ing. Rolf Jakoby</td></tr>
</table>

1	**Teaching content** First, there will be an introduction of different radar techniques, describing their concepts and principles, their applications and the operating frequency ranges. In a historical survey, the radar ranges and propagation effects will be dealt with. In the second part, various primary and secondary radar techniques will be investigated in detail, including specific techniques of radar signal processing and -analysis.
2	**Learning objectives** Students will know about concepts and principles to detect objects as well as to determine the angular position and range of objects. They learn about the functional principles of various radar systems, including signal processing. They will understand the major physical propagation effects.
3	**Recommended prerequisites for participation** Fundamentals of Communications, Microwave Engineering I
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. iCE, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Slides, Latest Publications and Books

Courses

<table>
<tr><td>Course nr.
18-jk-2040-vl</td><td colspan="2">Course name
Radar Techniques</td></tr>
<tr><td>Instructor
Prof. Dr.-Ing. Rolf Jakoby, Dr.-Ing. Alejandro Sáez</td><td>Type
Lecture</td><td>SWS
2</td></tr>
</table>

Module name Microwaves in Biomedical Applications					
Module nr. 18-jk-2110	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1	**Teaching 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** 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 prerequisites for participation** Fundamentals of electrical engineering
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** The script is provided and a list with recommended literature is presented in the lecture.

Courses

Course nr.	**Course name**		
18-jk-2110-vl	Microwaves in Biomedical Applications		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Jakoby, Dr.-Ing. Martin Schüßler		Lecture	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					
Microwave Engineering II					
Module nr. 18-jk-2130	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1 **Teaching content**

Part 1 Passive microwave components:
- Calculation of the two-port parameters of simple passive components and circuits (transmission lines and lumped elements) for MMICs
- Wave parameters and S-parameters
- Smith chart and matching circuits with line elements or lumped elements
- Design and equivalent circuits of passive microwave components (transmission lines, capacitors, inductors and resistors)

Part 2 Active microwave components:
- Design and equivalent circuits of field effect transistors (FET) and heterostructure transistors (HEMTs)
- Gain and cut-off frequencies
- Schottky contacts: function and characteristics

Part 3 Active microwave circuits (main part):
- FET amplifiers: operation, equivalent circuit, gain, matching circuit, stability and circuit implementation
- Oscillator design
- Mixer design
- Material choice (compound semiconductor material systems: properties, fabrication and requirements)

Applications of these circuits range from communication systems such as cell phones to satellite transceivers as well as high-frequency sources up to Terahertz.
Topics of good scientific practice, as well as societal or ethical aspects of product design, optimization, and algorithms are addressed in an accompanying manner, where technically appropriate.

2 **Learning objectives**
After successful completion of the module students understand the physics of microwave waveguides, resonators, microwave components (passive and active) as well as microwave circuits.

3 **Recommended prerequisites for participation**
Introduction to Electrodynamics, Microwave Engineering I

4 **Form of examination**
Module exam:
- Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)

5 **Prerequisite for the award of credit points**
Passing the final module examination

6 **Grading**
Module exam:
- Module exam (Technical examination, Examination, Weighting: 100 %)

7 **Usability of the module**
M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. iCE, B.Sc. und M.Sc. iST

8 **Grade bonus compliant to §25 (2)**

9 **References**
Script and slides will be handed out. Literature will be recommended in the lecture.

Courses

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-jk-2130-vl</td><td colspan="3">Course name
Microwave Engineering II</td></tr>
<tr><td colspan="2">Instructor
PD Dr.-Ing. Oktay Yilmazoglu</td><td>Type
Lecture</td><td>SWS
3</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-jk-2130-ue</td><td colspan="3">Course name
Microwave Engineering II</td></tr>
<tr><td colspan="2">Instructor
PD Dr.-Ing. Oktay Yilmazoglu</td><td>Type
Practice</td><td>SWS
1</td></tr>
</table>

Module name High Voltage Technology II					
Module nr. 18-kc-2010	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** Prof. Dr. Myriam Koch		

1	**Teaching content** Liquid dielectrics, solid dielectrics, partial discharges, ageing of insulating materials, insulating capacity as a random variable, arcing and arc extinction
2	**Learning objectives** After successful completion of the module, the students are able to optimize insulation systems by choice of the dielectrics, by capacitive, refractive or resistive internal grading systems or by external geometrical/capacitive grading elements; they have understood why equipment is designed as it is and how and where it can or has to be optimized if requirements from service are changing; they have understood the physical phenomena behind the dielectric breakdown of gases and do know which are the main influencing parameters; they know the effect of strongly inhomogeneous electrode configurations and of extremely large gaps; they know the time dependencies of a dielectric breakdown and their impact on dielectric strength under impulse voltage stress; they are able to identify critical surface discharge configurations, know about the problems under severe external pollution of insulators and how to solve them; they are thus qualified to predict the dielectric strength of any electrode configuration under any kind of voltage stress and to design a particular required dielectric strength of equipment; they are particularly enabled to realize the demands of emerging UHV systems and to manage them; they have understood the mechanism of thunderstorms and lightning flashes and are able to derive protective measures for buildings, substations and overhead lines; they are skilled to calculate travelling wave effects and their effect on fast-front overvoltages and to develop adequate countermeasures.
3	**Recommended prerequisites for participation** High Voltage Technology I
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS) The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 21 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	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** • Küchler, A.: High Voltage Technology, Springer • Beyer, M.; Boeck, W.; Möller, K.; Zaengl, W.: Hochspannungstechnik, Springer-Verlag
Courses	

	Course nr. 18-kc-2010-vl	**Course name** High Voltage Technology II		
	Instructor Prof. Dr. Myriam Koch		**Type** Lecture	**SWS** 2
	Course nr. 18-kc-2010-ue	**Course name** High Voltage Technology II		
	Instructor Prof. Dr. Myriam Koch		**Type** Practice	**SWS** 1

Module name					
High Voltage Switchgear and Substations					
Module nr. 18-kc-2020	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. Claus Neumann		

1 Teaching content

This lecture covers the basic designs of high voltage substations as well as the design and working principles of high voltage switchgear:

- Switching processes and stresses induced by switching
- Arc behaviour in air, SF6 and vacuum
- Types of switchgear: earthing switches, disconnectors and circuit breakers
- Design and working principles of earthing switches and disconnectors in air and SF6
- Design and working principles of circuit breakers: vacuum breakers, pressured air and SF6 breakers (thermal blast and self-blast chambers)
- Stresses on earthing switches and disconnectors in the event of short circuit
- Testing of switchgear
- Reliability of switchgear
- Future developments: Intelligent control of switchgear, static switches, superconducting switchgear

2 Learning objectives

The student should understand the purpose and working principles of high voltage switchgear as well as their usage in high voltage substations.

3 Recommended prerequisites for participation

Prior attendance of the lectures High Voltage Technology I and II is recommended

4 Form of examination

Module exam:

- Module exam (Technical examination, Oral examination, Duration: 45 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Technical examination, Oral examination, Weighting: 100 %)

7 Usability of the module

M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

A script of the lecture (in German) and the lecture slides will be provided.

Courses

Course nr.	Course name		
18-kc-2020-vl	High Voltage Switchgear and Substations		
Instructor		**Type**	**SWS**
Prof. Dr. Claus Neumann, M.Sc. Manuel Philipp		Lecture	2

Module name Lightning Physics and Lightning Protection					
Module nr. 18-kc-2030	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. Myriam Koch		

1 Teaching content

- Thunderstorms and Cloadclassification, formation and electrification
- Lightning, terminology, types, charge transfer, typical parameters
- Streamer- leader process, inception and development in large gaps
- Electric and magnetic fields in vicinity of lightning discharge
- Return stroke models, charge distributions and neutralization
- The Finite-Difference Time Domain Method for solving Maxwell's equations
- Lightning location, the technical use of field information
- Lightning effects in the middle and upper atmosphere
- Lightning hazard and deleterious effects
- Lightning protection and related threats, historical overview, standards and present lightning protection concepts
- Outer lightning protection, Lightning rods, down conductors, grounding systems, potential bonding and separation distances
- Inner lightning protection, surge protection devices, installation, test standards
- Lightning protection on transmission lines, faults and effects, calculation of outage rates and opportunities of improvement
- Lightning and surge protection for wind turbines

2 Learning objectives

After successful completion of the module, the students know the inception, development and effects of natural lightning. They are able to differentiate between types of lightning and know all typical parameters, related to different surges and types of lightning. They know that the parameters may differ in different places over the earth and know the reason for this deviation. The students learn about all relevant components of a lightning strike as well as their technical relevance in lightning protection, surge protection and lightning location. The theory and most relevant models of lightning attachment and also its successive return stroke are known. All relevant lightning threats in terms of lightning protection are known and can be calculated.
The students know how a standardized lightning protection system has to look like. They know about lightning protection levels, lightning protection zones and are able to apply measures on building, transmission lines and wind mills. The students know about simulation methodologies used in lightning research, taking into account the full retarded Maxwell equations. The students are aware of the uncertainties in lightning protection and lightning research. They know about open questions in the field of research related to the inception, discharge and effects of lightning.
The students learn about unconventional lightning protection, which cannot be found in the standard, and also get to know why they are not found there. The students are sensitized about research results in general.

3 Recommended prerequisites for participation

Recommended: BSc etit, BSc Wi-etit

4 Form of examination

Module exam:

- Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS)

The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 10 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 Prerequisite for the award of credit points

	Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture slides and other information material supporting the lecture will be provided. IEC test standards can be leant out for use during the lecturer time. • Blitz und Blitzschutz, F. Heidler, K. Stimper, ISBN 978-3-8007-2974-6 • Handbuch für Blitzschutz und Erdung, P. Hasse, J. Wiesinger, W. Zischank, ISBN 978-3-7905-0657-0 • Blitzschutzanlagen: Erlauterungen zu DIN 57 185/VDE 0185, VDE-Verlag, ISBN 978-3-8007-1303-9 • Lightning, Physics and Effects, V.A. Rakov, M.A. Uman, ISBN 978-0-521-03541-5 • Lightning Physics and Lightning Protection, E.M. Bazelyan, Y.P. Raizer, ISBN 978-0-750-30477-1 • Electromagnetic Computation Methods for Lightning Surge Protection Studies, Y. Baba, V.A. Rakov, ISBN 978-1-118-27563-4 • Lightning Electromagentics, V. Cooray, ISBN 978-1-84919-215-6 • Lightning: Principles, Instruments and Application, H.D. Betz, U. Schumann, P. Laroche, ISBN 978-1-4020-9078-3

Courses

Course nr.	Course name		
18-kc-2030-vl	Blitzphysik und Blitzschutz		
Instructor		**Type**	**SWS**
Dr.-Ing. Martin Hannig		Lecture	2

Module name Power Cable Systems					
Module nr. 18-kc-2060	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr. Myriam Koch		

1	**Teaching content** In the lecture, in addition to theoretical knowledge, also the practical side of high voltage cable technology will be treated. These are technical issues, e.g. water sensitivity of plastic cables, cable inspection, testing of already installed cables and the latest developments as in the field of superconductivity etc.. The contents of the lecture are: • Cable construction: materials / requirements / design • Cable Manufacturing: conductors / extrusion / shield / sheath (oil-paper insulation) / reinforcement • Quality requirements and routine-/selection-/type- long term test / ISO 9001, standards, aging, endurance • Cable junction technique: sockets / terminations / materials / field grading systems / cable connection • Cable Systems: load / mech. requirements / ind. voltage / short circuit requirements / transient requirements / installation techniques • Design and operation: route planning / laying / commissioning / monitoring / maintenance • Trends: High-temperature superconductivity, Submarine cable, DC cable, forced cooling, GIL
2	**Learning objectives** Students learn the basic structure of a cable. They know the technical requirements both for the material and the design of a high voltage cable. The basics of manufacturing technology and the necessary tests are learned. The students are also able to evaluate new trends in cable technology.
3	**Recommended prerequisites for participation** BSc. ETiT Electrical Power Systems
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 4 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	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Slides, litrature sources
Courses	

	Course nr.	Course name		
	18-kc-2060-vl	Power Cable Systems		
	Instructor		**Type**	**SWS**
	M.Sc. Tobias Trautmann, Dr. Ing. Johannes Kaumanns		Lecture	2

Module name Electromagnetic Compatibility					
Module nr. 18-kc-2070	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Myriam Koch		

1	**Teaching content** Fundamentals of Electromagnetic Compatibility, sources of emission, coupling mechanisms and counter measures, components for noise suppression, electromagnetic shields, EMC measuring and test techniques, excursion to VDE Offenbach
2	**Learning objectives** The students know that from every electromagnetic system a interaction is possible and that every electromagnetic (and also biological) system can be effected; they can differ between typical interference sources and sinks; they know the typical coupling paths and can identify and describe them mathematically; they know the basic methods to avoid interference at the source side and can derive their own actions against interference from this basic understanding; they know the basic actions to avoid interference at the sink side and can also derive actions to avoid interference; they have the ability to recognize coupling paths and can systematically influence or interrupt them completely; they know the situation of the EMC standardization and know basically which requirements have to be fulfilled and how to do this (also i.e. how to give a device a CE-label); they have learned the most important EMC testing and measurement techniques theoretically and practically know on the field trip.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS) The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 20 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** • All lecture slides (ca. 500 pcs.) available for download • Adolf J. Schwab: Elektromagnetische Verträglichkeit, Springer-Verlag • Clayton R. Paul: Introduction to Electromagnetic Compatibility, Wiley & Sons

Courses

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-kc-2070-vl</td><td colspan="3">Course name
Electromagnetic Compatibility</td></tr>
<tr><td colspan="2">Instructor
Dr. Ing. Torsten Psotta</td><td>Type
Lecture</td><td>SWS
2</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-kc-2070-ue</td><td colspan="3">Course name
Electromagnetic Compatibility</td></tr>
<tr><td colspan="2">Instructor
Dr. Ing. Torsten Psotta</td><td>Type
Practice</td><td>SWS
1</td></tr>
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<table>
<tr><td colspan="6">Module name
Relativistic Electrodynamics</td></tr>
<tr><td>Module nr.
18-kb-2020</td><td>Credit points
5 CP</td><td>Workload
150 h</td><td>Self-study
90 h</td><td>Module duration
1 Term</td><td>Module cycle
Winter term</td></tr>
<tr><td colspan="3">Language
German/English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Harald Klingbeil</td></tr>
</table>

1	**Teaching content** Basics of tensor analysis (tensor fields, transformation behavior, invariance, Ricci calculus, covariant derivative, differential operators), Lorentz transform, fundamental relativistic effects (time dilation, length contraction, Doppler effect), covariant form of Maxwell's equations, induction law from relativistic point of view, relation to relativistic mechanics, four-vectors and four-tensors, electromagnetic energy-momentum tensor and Maxwell's stress tensor, applications of relativistic electrodynamics
2	**Learning objectives** The students understand the basic ideas of Special Relativity and are familiar with the scientific vocabulary. They are able to derive and interpret fundamental formulas, and they are familiar with the mathematical tools. The students understand the concept of covariance and a coordinate-free description of physical theories. They are able to quantitatively compute electromagnetic phenomena in the context of Special Relativity.
3	**Recommended prerequisites for participation** "Grundlagen der Elektrodynamik" (18-dg-1010)
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - SAE, M.Sc. etit - EET, M.Sc. CE, M.Sc. etit - CMEE
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture slides are offered for download. Further references are given in the lecture.

Courses

Course nr.	Course name		
18-kb-2020-vl	Relativistic Electrodynamics		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Harald Klingbeil		Lecture	2

Course nr.	Course name		
18-kb-2020-ue	Relativistic Electrodynamics		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Harald Klingbeil, M.Sc. Sebastian Orth, M.Sc. Yi Jin, M.Sc. Christoph Wegmann		Practice	2

Module name Radio Frequency Systems for Particle Accelerators					
Module nr. 18-kb-2040	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Harald Klingbeil		

1	**Teaching content** Repetition of transmission lines and waveguides, S-parameters. RF components, RF measurements, cavities loaded with magnetically permeable materials, cavities based on classical resonators, cavity equivalent circuit, beam loading, basic terms and definitions of nonlinear dynamics, RF acceleration, longitudinal phase space, particle tracking equations, Liouville's theorem, adiabaticity, RF systems for special beam manipulations, closed-loop and open-loop control (LLRF) systems.
2	**Learning objectives** Students know important RF components and sub-systems for particle accelerator cavities. They are able to describe them mathematically (e.g. by means of S-parameters), and they are familiar with the operating principle of different types of cavities for particle accelerators and their sub-systems and components. The description of RF manipulations in longitudinal phase space and related terms and definitions are known to them. The students are able to calculate different phenomena of accelerator technology quantitatively.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. etit - KTS, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - CMEE
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture slides are offered for download. Further references are given in the lecture.

Courses

Course nr.	**Course name**		
18-kb-2040-vl	Radio Frequency Systems for Particle Accelerators		
Instructor Prof. Dr.-Ing. Harald Klingbeil		**Type** Lecture	**SWS** 2

Course nr.	**Course name**		
18-kb-2040-ue	Radio Frequency Systems for Particle Accelerators		
Instructor Prof. Dr.-Ing. Harald Klingbeil, M.Sc. Sebastian Orth, M.Sc. Yi Jin, M.Sc. Christoph Wegmann		**Type** Practice	**SWS** 2

Module name Lighting Technology I					
Module nr. 18-kh-2010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Tran Quoc Khanh		

1 Teaching content

Structure and functionality of the human eye, terms and unit in lighting technology, photometry, radiometric and photometric properties of materials, filters, physiology of vision, colour theory, lighting, light sources. Measurement of luminous flux, luminous intensity, illuminance, luminance, determination of the spectral responsivity function of the human eye, colorimetry colour rendering, colour as traffic signals, measuring of optical material characteristics, LED properties

2 Learning objectives

On completion of the module students will have learned the following:

- To list and connect terms, units and radiometric and photometric properties of materials in lighting technology
- to describe and understand structure and functionality of the human eye and the physiology of vision
- to illustrate basics of lighting, measuring methods and application.

They are able to measure base items in lighting technology, applying knowlegde of lighting and enhance them with experiments and have developed a better understanding for light and color.

3 Recommended prerequisites for participation

MSc ETiT, MSc Wi-ETiT, MSc MEC

4 Form of examination

Module exam:

- Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Technical examination, Oral examination, Weighting: 100 %)

7 Usability of the module

B.Sc. etit, M.Sc. MEC, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. MedTec, B.Sc. und M.Sc. iST, B.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

9 References

Script for lecture: Lighting Technology I
Excersisebook: laboratory: lighting technology I

Courses

Course nr.	**Course name**	
18-kh-2010-vl	Lighting Technology I	
Instructor	**Type**	**SWS**
Prof. Dr.-Ing. Tran Quoc Khanh, Dr.-Ing. Babak Zandi, M.Sc. Felix Wirth	Lecture	2

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-kh-2010-pr</td><td colspan="3">Course name
Lighting Technology I</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Tran Quoc Khanh, Dr.-Ing. Babak Zandi, M.Sc. Felix Wirth</td><td>Type
Lab</td><td>SWS
2</td></tr>
</table>

Module name Advanced Lighting Technology					
Module nr. 18-kh-2020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Tran Quoc Khanh		

1	**Teaching content** Chosen topics in lighting technology - current developments and applications: Street lighting, Physiology: Detektion / Glare / Lighing and Health, LED - Generation of white Light / State of the Art, Modern Methods of Light Measurement, Interiour Lighting, Display Technologies, Non-visual Light Impacts,UV-Applications, Automotive Lighting, Solar Modules.
2	**Learning objectives** On completion of the module students will have learned the following: They know current developments and applications, list and connect terms, to illustrate special topics of lighting, measuring methods and application. They are able to measure base items in lighting technology, applying knowlegde of lighting and dedicated applications and further to enhance them with experiments. They have developing a better understanding for light, color, perception and lighting situations.
3	**Recommended prerequisites for participation** Lighting Technology I
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. MedTec, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Excercisebook: laboratory: lighting technology II

Courses

Course nr.	**Course name**	**Instructor**	**Type**	**SWS**
18-kh-2020-vl	Advanced Lighting Technology	Prof. Dr.-Ing. Tran Quoc Khanh	Lecture	2
18-kh-2020-pr	Advanced Lighting Technology	Prof. Dr.-Ing. Tran Quoc Khanh	Lab	2

Module name Optical Technologies in Car Lighting					
Module nr. 18-kh-2041	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Tran Quoc Khanh		

1	**Teaching content** History and standardisation of car lithing. Description of the oused lighting sources and the function of these(lowbeam, highbeam, bending light, stop lamp, daytime running light…), visuell perception, glare, detection, traffic infrastructure, traffic elements, interior lighting, driver assistance systems(GPS, Radar, Lidar…), methods of psychophysics, lighting application concepts in future automated vehicles. Voluntary trip planed to an automobile manufacturer
2	**Learning objectives** Upon completion of the module, students will have learned to describe the basics and deepening knowledge of car lighting, to understand the light distribution of head and rear lamps, to learn the basics of standardisation, enlarge glare and detection skills, know the traffic elements, as well as the driver assistance systems.
3	**Recommended prerequisites for participation** Lighting technology 1
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - SAE, M.Sc. WI-etit, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture slides, Automotive Lighting and Human Vision, Handbuch Fahrassistenzsysteme

Courses

Course nr.	**Course name**		
18-kh-2041-vl	Optical Technologies in Car Lighting		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Tran Quoc Khanh		Lecture	2
Course nr.	**Course name**		
18-kh-2041-pr	Optische Technologien im KFZ-Bereich		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Tran Quoc Khanh		Lab	1

Module name					
Solid State Lighting					
Module nr. 18-kh-2060	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Tran Quoc Khanh		

1	**Teaching content** Basics of light and colour perception; basics of solid state light sources; LEDs: material systems, structural shape, optics, phosphors; phosphor mixtures; colour and white LEDs; temperature, current and optical behaviour of LEDs; LED models; lifetime and defect mechanisms of LEDs; OLEDs and semiconductor lasers in lighting engineering; optical sensors; semiconductor based cameras; colour sensors; colour quality of solid state light sources; choice and combination of LEDs in practical LED luminaires; flicker; grouping (binning) of LEDs according to their technological parameters; lighting quality metrics; intelligent indoor lighting with LEDs: colour recognition, spectral reconstruction; intelligent automotive and outdoor lighting with LEDs; practical training: thermic, electric and lighting engineering related measurement of LED light sources.
2	**Learning objectives** Principles and applications of the technology of solid state light sources in lighting engineering; LED technology and the optimisation of visual perception under LED light in modern lighting engineering.
3	**Recommended prerequisites for participation** Lichttechnik I, II
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE
8	**Grade bonus compliant to §25 (2)**
9	**References** • LED-Lighting: Technology and Perception (Khanh, Bodrogi, Vinh, Winkler; Editors,Wiley-VCH,2015) • Introduction to Solid State Lighting (Zukauskas et al., Wiley, 2002) • Light Emitting Diodes (Schubert; Cambridge Univ. Press, 2003)

Courses

Course nr.	Course name		
18-kh-2060-vl	Solid State Lighting		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Tran Quoc Khanh, Dr.-Ing. Alexander Herzog		Lecture	2

	Course nr.	Course name		
	18-kh-2060-pr	Praktikum Halbleiterlichttechnik		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Tran Quoc Khanh, Dr.-Ing. Alexander Herzog		Lab	2

Module name Communication Technology II					
Module nr. 18-kl-2010	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Anja Klein		

1	**Teaching content** Linear and nonlinear digital modulation schemes, optimum receivers for AWGN channels, error probability, channel capacity, channel models, channel estimation and data detection for multipath channels, multicarrier schemes, OFDM
2	**Learning objectives** After completion of the lecture, students possess: • the ability of comparing, evaluating, classifying an analyzing linear and nonlinear modulation schemes by means of signal space representations; • the ability to understand, describe and analyze the influence of AWGN on the signal; • the ability to understand and derive optimum receivers in case of AWGN channels; • the ability to understand, describe and analyze the influence of multipath propagation on the signal; • the ability to describe the influence of a multipath channel mathematically (channel model) and estimate the multipath channel at the receiver; • the knowledge of equalizing the received signal in order to undo the influence of multipath propagation, as well as the ability to derive and design several equalizer structures; • the ability to analyze and evaluate the properties and application areas of multicarrier transmission systems, e.g. OFDM-systems; • the ability to design and evaluate the system parameters of multicarrier schemes for the application in realistic wireless communication scenarios; • the ability to mathematically express and analyze all above system models in matrix-vector-notation.
3	**Recommended prerequisites for participation** Deterministische Signale und Systeme, Communication Technology I, Basics of Telecommunication, Mathematics I to III, Statistics/Probability Theory, Scientific Computing
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**References** will be announced in the lecture
Courses	

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-kl-2010-vl</td><td colspan="3">Course name
Communication Technology II</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Anja Klein</td><td>Type
Lecture</td><td>SWS
2</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-kl-2010-ue</td><td colspan="3">Course name
Communication Technology II</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Anja Klein, M.Sc. Yi Wang, M.Sc. Sumedh Dongare</td><td>Type
Practice</td><td>SWS
2</td></tr>
</table>

Module name Mobile Communications					
Module nr. 18-kl-2020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Anja Klein		

1 Teaching content

The lecture covers aspects of mobile communication systems with particular focus on the physical layer.

- Mobile radio systems, services, market, standardization
- Duplex and multiple access techniques, cellular concept
- Mobile radio channel, deterministic and stochastic description
- Modulation schemes
- Code division multiple access (CDMA)
- Orthogonal frequency division multiplexing (OFDM)
- Optimum and suboptimum receiver techniques
- Cellular radio capacity and spectrum efficiency
- Diversity methods
- Multiple input multiple output (MIMO) systems
- Power control and handover
- Architecture of mobile radio systems

2 Learning objectives

After completion of the module, students possess

- a profound understanding of physical layer aspects ,e.g., transmission schemes, multiple access schemes of mobile communication systems, duplex schemes, multi carrier schemes, receiver techniques, multi antenna schemes
- a profound understanding of signal propagation in mobile radio systems (mobile radio channel)
- the ability to understand and solve problems of the field of the physical layer
- the ability to compare, analyse and evaluate different system concepts
- knowledge on modelling of the transmission properties of the mobile radio channel

3 Recommended prerequisites for participation

Deterministic Signals and Systems, Communication Technology I, Mathematics I to III, Statistics/Probability Theory, Scientific Computing

4 Form of examination

Module exam:

- Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

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

7 Usability of the module

M.Sc. WI-etit, M.Sc. etit - KTS, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS

8 Grade bonus compliant to §25 (2)

9 References

	will be announced in the lecture

Courses

Course nr.	Course name		
18-kl-2020-vl	Mobile Communications		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Anja Klein, Dr.-Ing. Lin Xiang		Lecture	3
Course nr.	**Course name**		
18-kl-2020-ue	Mobile Communications		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Anja Klein, Dr.-Ing. Lin Xiang		Practice	1

Module name					
Fundamentals of Reinforcement Learning					
Module nr. 18-kl-2070	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Anja Klein		

1 Teaching content

- Review of Probability Theory
- Markov Property and Markov Decision Processes
- The Multi-Armed Bandit Problem vs. the Full Reinforcement Learning Problem
- Taxonomy of Multi-Armed Bandit Problems (e.g., Stochastic vs. Adversarial Rewards, Contextual MAB)
- Algorithms for Multi-Armed Bandit Problems (e.g., Upper Confidence Interval (UCB), Epsilon-Greedy, SoftMax, LinUCB) and their Application to Cyber-Physical Networking
- Fundamentals of Dynamic Programming and Bellman Equations
- Taxonomy of Approaches for the Full Reinforcement Learning Problem (e.g., Temporal-Difference Learning, Policy Gradient and Actor-Critic)
- Algorithms for the Full Reinforcement Learning Problem (e.g., Q-Learning, SARSA, Policy Gradient, Actor-Critic) and their Application to Cyber-Physical Networking
- Linear Function Approximation
- Non-linear Function Approximation

2 Learning objectives

The students are able to

- define the Markov property and identify the elements that constitute a Markov decision process. They will be able to use these concepts to model decision-making problems in Cyber-Physical Networking.
- determine the characteristics of the Multi-Armed Bandit (MAB) Problem and compare them to the characteristics of the Full Reinforcement Learning (RL) Problem.
- determine under which conditions the MAB or the full RL formulation should be used to solve decision-making problems.
- differentiate the main MAB strategies, e.g., Upper Confidence Interval (UCB), Epsilon-Greedy and Softmax.
- choose appropriate MAB strategies for the solution of MAB problems.
- formulate and solve Contextual-MAB problems.
- determine under which conditions Dynamic Programming can be used to solve decision-making problems.
- explain the difference between Dynamic Programming and RL methods.
- differentiate between Temporal-Difference, Policy Gradient and Actor-Critic RL techniques.
- identify the limitations of MAB and full RL problems.
- explain the need for generalization in MAB and full RL problems.
- choose appropriate approximation techniques and use them in combination with MAB and full RL strategies.
- apply algorithmic techniques to solve MAB and full RL problems and obtain valid solutions.
- judge the reasonableness and consistency of the obtained solutions.

3 Recommended prerequisites for participation

- Python or Matlab: basic knowledge
- Engineering mathematics and probability theory

4 Form of examination

	Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 60 Min., Default RS) The examination takes place in form of a written exam (duration: 60 minutes). If one can estimate that less than 21 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. WI-etit, M.Sc. etit - KTS, M.Sc. etit - AUT, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**References** • Richard S. Sutton and Andrew G. Barto, "Reinforcement Learning: An Introduction", A Bradford Book, Cambridge, MA, USA, 2018. • Aleksandrs Slivkins, "Introduction to Multi-Armed Bandits", Foundations and Trends in Machine Learning, Vol. 12: No. 1-2, 2019.

Courses

Course nr.	Course name	Instructor	Type	SWS
18-kl-2070-vl	Fundamentals of Reinforcement Learning	Dr. rer. nat. Sabrina Klos, Dr.-Ing. Andrea Jimenez	Lecture	2
18-kl-2070-ue	Fundamentals of Reinforcement Learning		Practice	1

Module name Sensor Technique					
Module nr. 18-kn-2120	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Teaching content** The module teaches basic principles of different sensors and the required knowledge for correct application of sensors. With regard to the measurement chain, the focus of the course is on the conversion of any, generally non-electrical quantities into electrically evaluable signals. Resistive, capacitive, inductive, piezoelectric, optical, and magnetic measurement principles are covered in the module to provide knowledge of the measurement of important quantities such as force, torque pressure, acceleration, velocity, displacement, and flow. In addition to a phenomenological description of the principles and a derived technical description, the main elements of primary and secondary electronics for each measurement principle will also be presented and understood. In addition to the measurement principles, the description of errors will be dealt with. In addition to static and dynamic errors, errors in signal processing and error consideration of the entire measurement chain will be discussed. In the exercises the method of peer instruction is utilized.
2	**Learning objectives** 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 prerequisites for participation** Measuring Technique
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. MedTec, B.Sc. und M.Sc. iST, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**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, M.Sc. Sven Suppelt		**Type** Lecture	**SWS** 2
	Course nr. 18-kn-2120-ue	**Course name** Sensor Technique		
	Instructor Prof. Dr. Mario Kupnik, M.Sc. Sven Suppelt		**Type** Practice	**SWS** 1

Module name					
Data-driven Modeling - Machine Learning					
Module nr. 18-kp-2110	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr. techn. Heinz Köppl		

1 Teaching content

The module provides an introduction to the emerging field of machine learning from an engineering perspective. Important models and learning methods are presented and exemplified through problems from information and communication technology.

- Fundamentals of probability theory and multivariate statistics
- Taxonomy of machine learning problems and models (supervised, unsupervised, generative, discriminative)
- Regression and classification: theory, methods and ICT applications
- Dimensionality reduction, clustering and big data analytics: methods and application in communications and signal processing
- Probabilistic graphical models: categories, inference and parameter estimation
- Fundamentals of Bayesian inference, Monte Carlo methods, Bayesian non-parametrics
- Fundamentals of convex optimization: Solution methods and application in communications
- Approximate algorithms for scalable Bayesian inference; application in signal processing and information theory (e.g. decoding of LDPC codes)
- Hidden Markov models (HMM): Theory, Algorithms and ICT applications (e.g. Viterbi decoding of convolutional codes)
- High-dimensional statistics ("large p small n" setting), learning dependency structure in high-dimensional data, learning causality relations from observational data.
- Sparse estimation, random projections, compressive sensing: Theory and applications in signal processing
- Deep neural networks (deep learning): Models, learning algorithms, libraries and ICT applications

2 Learning objectives

Students are able to interpret and categorize specific engineering problems from the ICT domain in terms of machine learning problems.

They are able to reduce such problems to standard machine learning problems and are able to determine suitable solution methods for them.

They are able to implement all necessary algorithms from scratch, but they are also familiar with the state-of-the-art libraries in machine learning.

They are able to determine the involved computational complexity of a method and choose an appropriate solution algorithms based on application constraints.

They are able to apply the acquired methods to other domains, such as data analysis in biomedical engineering, analysis of social network data, etc.

3 Recommended prerequisites for participation

Good command of Matlab (for instance knowledge from course 18-st-2030 Matlab Grundkurs) and engineering mathematics

4 Form of examination

Module exam:

- Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS)

The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 10 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	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, B.Sc. CE, M.Sc. iCE, B.Sc. und M.Sc. iST, B.Sc. WI-etit, M.Sc. etit - CMEE, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**References** • Kevin P. Murphy. Machine Learning - A probabilistic perspective, MIT Press, 2012 • Christopher M. Bishop. Pattern recognition and Machine Learning, Springer, 2006 • Peter Bühlmann und Sara van de Geer. Statistics of high-dimensional data - Methods, theory and applications, Springer, 2011

Courses

Course nr.	Course name	Instructor	Type	SWS
18-kp-2110-vl	Data-driven Modeling - Machine Learning	Prof. Dr.-Ing. Anja Klein, Prof. Dr. techn. Heinz Köppl	Lecture	2
18-kp-2110-ue	Data-driven Modeling - Machine Learning	Prof. Dr.-Ing. Anja Klein, Prof. Dr. techn. Heinz Köppl	Practice	1
18-kp-2110-pr	Data-driven Modeling - Machine Learning Lab	Prof. Dr.-Ing. Anja Klein, Prof. Dr. techn. Heinz Köppl	Lab	1

Module name Bioinformatics II					
Module nr. 18-kp-2120	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr. techn. Heinz Köppl		

1 Teaching 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

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 prerequisites for participation

Bioinformatics I

4 Form of examination

Module exam:
- Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)

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 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. WI-etit, M.Sc. MedTec, M.Sc. etit - CMEE

8 Grade bonus compliant to §25 (2)

9 References

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

Module name Introduction to Spintronics					
Module nr. 18-me-2020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr. rer. nat. Markus Meinert		

1	**Teaching content** The lecture covers the following subjects: • Basics of atomic physics (structure of the atoms, electron hull) • Basics of solid state physics (crystalline materials) • Introduction to electron transport in solids (classical treatment, band structures) • Basic notions and simple models of magnetism • Magnetism in thin films • Spin-dependent electronic transport • Magnetoresistive effects, anisotropic magnetoresistance • Giant magnetoresistance (GMR) • Tunneling magnetoresistance (TMR) • Spin-Transfer Torque • Magnetic microwave oscillators • Spin-Hall effect and other spin-orbit effects • Materials for spintronics (ferromagnets, antiferromagnets) • Magnetic data storage • Spintronic devices as sensors • Magnetic random-access memory (MRAM)
2	**Learning objectives** The students learn fundamental concepts of spintronics, from properties of magnetic materials to the design and application of spintronic devices in data storage and magnetic sensing. The students acquire the competence to make use of spintronic devices in applications. They further acquire the competence to understand current scientific literature and to dive deeper into the field.
3	**Recommended prerequisites for participation** Module 11-01-6419 Materials of Electrical Engineering
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS) The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 16 students register, the examination will be an oral examination (duration: 45 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - SAE, M.Sc. iCE
8	**Grade bonus compliant to §25 (2)** Yes
9	**References**

- A script will be made available electronically
- Coey, Magnetism and Magnetic Materials, 2009, Cambridge University Press
- Skomski, Simple Models of Magnetism, 2008, Oxford University Press
- Felser, Fecher, Spintronics: From Materials to Devices, 2013, Springer
- Dietl, Awschalom, Kaminska, Ohno, Spintronics, 2008, Academic Press
- Blachowicz, Ehrmann, Spintronics, 2019, de Gruyter
- Tsymbal, Zutic, Spintronics Handbook, Volume One: Metallic Spintronics, 2019, CRC Press
- Xu, Awschalom, Nitta, Handbook of Spintronics, 2016, Springer

Courses

Course nr.	**Course name**		
18-me-2020-vl	Introduction to Spintronics		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Markus Meinert		Lecture	3
Course nr.	**Course name**		
18-me-2020-ue	Introduction to Spintronics		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Markus Meinert		Practice	1

Module name Robust Data Science With Biomedical Applications					
Module nr. 18-mu-2010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Michael Muma		

1	**Teaching content** **Robust Data Science for Signal Processing** • Basics on robust statistical learning • Robust regression models • Robust clustering and classification • Robust time-series and spectral analysis • High-dimensional robust data science **Biomedical Applications** • Body-worn and radar-based sensing of vital signs • Electrocardiogram (ECG) and Photoplethysmogram (PPG) • Biomarker selection • Eye research • Genomics • Intracranial Pressure (ICP) The lecture covers fundamental topics and recent developments in robust data science. Unlike classical statistical learning and 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 data science and biomedical application lectures alternate. Exercises revise the theory and apply robust machine learning and signal processing algorithms to real world data. Software toolboxes in Python, Matlab and R that implement the lecture contents are available to the students.
2	**Learning objectives** 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 prerequisites for participation** Fundamental knowledge of statistical signal processing
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 180 Min., Default RS)
5	**Prerequisite for the award of credit points** Pass module final exam
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. MedTec, M.Sc. iCE, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**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-mu-2010-vl	Robust Signal Processing With Biomedical Applications		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Michael Muma		Lecture	3
Course nr.	**Course name**		
18-mu-2010-ue	Robust Data Science With Biomedical Applications		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Michael Muma		Practice	1

Module name					
Information Theory II: Networks					
Module nr. 18-pe-2010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Marius Pesavento		

1	**Teaching content** This lecture course is devoted to topics in network information theory. Outline: overview of Shannon capacity, outage and ergodic capacity, capacity of channels with state, capacity of Gaussian vector channels, capacity regions of multi-user channels, capacity regions of multiple-access and broadcast fading channels, interference channel, relay channel, multiuser bounds, graphical multi-hop networks, routing, network coding, capacity of MIMO multiple-access and broadcast channels, duality of MIMO multiple access and broadcast channels, dirty paper coding, multi-user diversity., wiretap channel, secrecy rate and physical layer security.
2	**Learning objectives** Upon completion of the module, students will have an understanding of the advanced concepts and strategies in network information theory.
3	**Recommended prerequisites for participation** Knowledge of basic communication theory
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS) The examination takes place in form of a written exam (duration: 120 minutes). If apparent that less than 10 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - CMEE, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**References** • Abbas El Gamal and Young-Han Kim, Network Information Theory, Cambrige, 2011. • T.M. Cover and J.A. Thomas, Elements of Information Theory, Wiley Sons, 1991. • D. Tse and P. Vishwanath, Fundamentals of Wireless Communications, Cambridge University Press, 2005.

Courses

Course nr.	Course name		
18-pe-2010-vl	Information Theory II: Networks		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Marius Pesavento		Lecture	3

	Course nr.	Course name		
	18-pe-2010-ue	Information Theory II: Networks		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Marius Pesavento		Practice	1

Module name					
Convex Optimization in Signal Processing and Communications					
Module nr. 18-pe-2020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Marius Pesavento		

1 Teaching content

This graduate course introduces the basic theory of convex optimization and illustrates its use with many recent applications in communication systems and signal processing.
Outline: Introduction, convex sets and convex functions, convex problems and classes of convex problems (LP, QP, SOCP, SDP, GP), Lagrange duality and KKT conditions, basics of numerical algorithms and interior point methods, optimization tools, convex inner and outer approximations for non convex problems, sparse optimization, distributed optimization, discrete optimization, mixted integer linear and non-linear programming, Branch-and-Bound method, Branch-and-Cut method, customized iterative optimization, Newton method, gradient projection method, conjugate gradient method, block coordinate descent method, successive convex approximation method, BSUM method, Majorization Maximization, difference-of-convex procedure, ADMM, step size selection, optimal step size compuation, applications.

2 Learning objectives

After completing the module, students will have become familiar with advanced topics in modern communication. This includes in particular the basic theory of convex optimization and its application in digital signal processing and mobile communication systems.

3 Recommended prerequisites for participation

Knowledge in linear algebra and the basic concepts of signal processing and communications.

4 Form of examination

Module exam:
- Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS)

The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 14 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. iCE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit, M.Sc. etit - CMEE, M.Sc. etit - VAS

8 Grade bonus compliant to §25 (2)

9 References

- S. Boyd and L. Vandenberghe, Convex Optimization, Cambridge University Press, 2004. (online Verfügbar: http://www.stanford.edu/ boyd/cvxbook/)
- D. P. Bertsekas, Nonlinear Programming, Athena Scientific, Belmont, Massachusetts, 2nd Ed., 1999.
- Daniel P. Palomar and Yonina C. Eldar, Convex Optimization in Signal Processing and Communications, Cambridge University Press, 2009.

Courses

	Course nr. 18-pe-2020-vl	**Course name** Convex Optimization in Signal Processing and Communications		
	Instructor Prof. Dr.-Ing. Marius Pesavento		**Type** Lecture	**SWS** 2
	Course nr. 18-pe-2020-ue	**Course name** Convex Optimization in Signal Processing and Communications		
	Instructor Prof. Dr.-Ing. Marius Pesavento		**Type** Practice	**SWS** 1
	Course nr. 18-pe-2020-pr	**Course name** Convex Optimization in Signal Processing and Communications Lab		
	Instructor Prof. Dr.-Ing. Marius Pesavento		**Type** Lab	**SWS** 1

Module name Sensor Array Processing and Adaptive Beamforming					
Module nr. 18-pe-2060	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Marius Pesavento		

1	**Teaching content** This lecture course introduces the principles of modern sensor array processing and adaptive beamforming. Outline: Motivation and background; applications, narrowband and wideband signal model Direction-of-arrival estimation (DoA): traditional methods based on beamforming, super resolution methods, Maximum-Likelihood methods, Subspace based methods, MUSIC, ESPRIT, MODE, root-MUSIC, multidimensional source localization, approximate Maximum Likelihood methods, Expectation Maximization (EM) algorithm, partial relaxation method, beamspace processing, array interpolation, partly calibrated arrays, wideband DOA estimation, spatial smoothing, forward-backward averaging, redundancy averaging, correlated sources, minimum redundancy arrays, compressed sensing and sparse reconstruction based DoA estimation, performance bounds Adaptive beamforming: Point-source model, covariance model, Wiener-Hopf equation, Minimum Variance Distortionless Response (MVDR) beamformer, Capon Beamformer, sample matrix inversion, signal self-nulling effect, robust adaptive beamforming, Hung-Turner projection beamformer, Generalized Sidelobe canceller beamformer, Eigenspace-based beamformer, non-stationary environments, modern convex optimization based beamforming, worst-case based beamforming, multiuser beamforming.
2	**Learning objectives** Upon completion of the module, students will have learned the application of theory and algorithms for processing Sensor-Arry and Tensor data.
3	**Recommended prerequisites for participation** Knowledge in linear algebra.
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS) The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 10 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. etit - KTS, M.Sc. iCE, B.Sc. und M.Sc. iST, B.Sc. WI-etit, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**References**

1. Academic Press Library in Signal Processing: Volume 3 Array and Statistical Signal Processing Edited by Rama Chellappa and Sergios Theodoridis, Section 2, Edited by Mats Viberg, Pages 457-967 (2014)
   a) Chapter 12 - Adaptive and Robust Beamforming, Sergiy A. Vorobyov, Pages 503-552
   b) Chapter 14 - DOA Estimation Methods and Algorithms, Pei-Jung Chung, Mats Viberg, Jia Yu, Pages 599-650
   c) Chapter 15 - Subspace Methods and Exploitation of Special Array Structures, Martin Haardt, Marius Pesavento, Florian Roemer, Mohammed Nabil El Korso, Pages 651-717
2. Spectral Analysis of Signals, Petre Stoica, Randolph Moses, Prentice Hall, April 2005Optimum Array Processing: Part IV of Detection, Estimation, and Modulation Theory, Harry L. Van Trees, Wiley Online, 2002.

Courses

Course nr.	Course name	Instructor	Type	SWS
18-pe-2060-vl	Sensor Array Processing and Adaptive Beamforming	Prof. Dr.-Ing. Marius Pesavento	Lecture	2
18-pe-2060-ue	Sensor Array Processing and Adaptive Beamforming	Prof. Dr.-Ing. Marius Pesavento	Practice	1

Module name Matrix Analysis and Computations					
Module nr. 18-pe-2070	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Marius Pesavento		

1	**Teaching content** This graduate course is a foundation class on matrix analysis and computations, which are widely used in many different fields, e.g., machine learning, computer vision, systems and control, signal and image processing, communications, networks, optimization, and many more… Apart from the theory this course will also cover the design of efficient algorithm and it considers many different examples from the aforementioned fields including examples from social media and big data analysis, image processing and medical imaging, communication network optimization, and written text classification. Specific topics: (i) basic matrix concepts, subspace, norms, (ii) linear least squares (iii) eigendecomposition, singular value decomposition, positive semidenite matrices, (iv) linear system of equations, LU decomposition, Cholesky decomposition (v) pseudo-inverse, QR decomposition (vi) advanced tensor decomposition, advanced matrix calculus, compressive sensing, structured matrix factorization
2	**Learning objectives** Students will have learned advanced topics in matrix analysis and related algorithms at an advanced level upon completion of the module.
3	**Recommended prerequisites for participation** Basic knowledge in linear algebra.
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS) The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 10 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Pass module final exam.
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, M.Sc. MEC, M.Sc. WI-etit, M.Sc. etit - KTS, M.Sc. etit - AUT, M.Sc. iCE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit, M.Sc. etit - CMEE
8	**Grade bonus compliant to §25 (2)**
9	**References**

- Gene H. Golub and Charles F. van Loan, Matrix Computations (Fourth Edition), John Hopkins University Press, 2013.
- Roger A. Horn and Charles R. Johnson, Matrix Analysis (Second Edition), Cambridge University Press, 2012.
- Jan R. Magnus and Heinz Neudecker, Matrix Differential Calculus with Applications in Statistics and Econometrics (Third Edition), John Wiley and Sons, New York, 2007.
- Giuseppe Calaore and Laurent El Ghaoui, Optimization Models, Cambridge University Press, 2014.
- ECE 712 Course Notes by Prof. Jim Reilly, McMaster University, Canada (friendly notes for engineers) http://www.ece.mcmaster.ca/faculty/reilly/ece712/course_notes.htm

Courses

Course nr.	Course name		
18-pe-2070-vl	Matrix Analysis and Computations		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Marius Pesavento		Lecture	3
Course nr.	**Course name**		
18-pe-2070-ue	Matrix Analysis and Computations		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Marius Pesavento		Practice	1

Module name Graph Signal Processing, Learning and Optimization					
Module nr. 18-pe-2080	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Marius Pesavento		

1 Teaching content

The course covers the following topics:

- Motivation, Applications
- Fundamentals
  - definition of graphs, classes of graphs, properties of graphs, signals defined over graphs
  - Adjecency matrix, Graph Laplacian, Graph shift operator
  - Covariance matrix, conditional dependence, precision matrix
- Graph signal processing
  - Consensus, Diffusion
  - Graph spectral analysis, Graph Fourier Transform
  - Total variational norm, Graph Frequencies
  - Bandlimited graph signals, smoothness
  - Graph filters, Graph sampling theorem
  - Applications
- Network topology inference
  - Link prediction
  - Association network inference
  - Tomographic network topology inference
  - Pearson product-moment correlation
  - Causality, Partial correlation
  - Conditional independence graph
  - Gaussian Markov Random Fields
  - Graphical LASSO, Graphical LASSO with Laplacian constraint
  - Applications
- Graph analysis
  - Subgraph identification
  - Cliques identification
- Optimization over graphs
  - Average consensus, diffusion, exact diffusion
  - Gradient tracking, push-sum algorithm, etc.
  - Applications
- Graph neuronal (convolutional) network

2 Learning objectives

Graph signal processing (i.e., the processing of signals defined over graphs) and network analysis form an interdisciplinary research field with numerous and diverse applications. Upon completion of the module, students will have gained systematic knowledge in graph signal processing theory, graph network analysis, graph topology learning, optimization in graph networks, and learning using graph neural networks. They have learned essential concepts, algorithms and application areas of graph signal processing.

3 Recommended prerequisites for participation

Basic knowledge in linear algebra and matrix analysis.

4 Form of examination

	Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS) In general, the examination takes place in form of a written exam (duration: 120 minutes). If up to 20 students register in semesters in which the lecture does not take place, there will will be an oral examination (duration: 20 min.). The type of examination will be announced within one working weeks after the end of the examination registration phase.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. MedTec, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - CMEE, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**References** • Lecture notes and slides can be downloaded here: – www.nts.tu-darmstadt.de – moodle • Further reading: – Petar M. Djuric, Cédric Richard, Cooperative and Graph Signal Processing, Academic Press, 2018, ISBN 9780128136775.

Courses

Course nr.	Course name		
18-pe-2080-vl	Graph signal processing, learning and optimization		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Marius Pesavento		Lecture	3
Course nr.	**Course name**		
18-pe-2080-ue	Graph signal processing, learning and optimization		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Marius Pesavento, M.Sc. Yufan Fan		Practice	1

Module name Terahertz Systems and Applications					
Module nr. 18-pr-2010	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr. rer. nat. Sascha Preu		

1 Teaching content

The lecture will give an overview of Terahertz applications, sources and detectors with the focus on photonic and semiconductor-based devices and Terahertz systems. Terahertz detection and generation will be discussed in detail for two types of highly important devices: Schottky diodes (mixers, multi-pliers and rectifiers) and photomixers (photo-diode based and photoconductive). The exercise, where performance parameters of the discussed devices will be derived for experimentally relevant cases, will help to deepen the understanding.
The last day will be used for a lab tour showing our measurements facilities and hands-on Experiments.

2 Learning objectives

After completion of this module, the student has gained basic knowledge in the fields of THz generation, detection, systems, and applications of THz radiation, with deepened knowledge in:

- A general overview about the state of the art in Terahertz technology
- Working principle, spectra and limits of continuous-wave photomixer systems
- Working principle of Schottky diode mixers/multipliers and rectifiers in the THz range
- THz Applications

3 Recommended prerequisites for participation

Bachelor in Electrical engineering, Physics, or Material Science
Helpful: Basic knowledge in semiconductor physics, High frequency 1

4 Form of examination

Module exam:

- Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)

The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 20 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

- Pass module final exam

6 Grading

Module exam:

- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. iCE

8 Grade bonus compliant to §25 (2)

9 References

- Yun-Shik Lee, „Principles of Terahertz Science and Technology,“ Springer 2009, ISBN 978-0-387-09540-0
- G. Carpintero et al., “Semiconductor Terahertz Technology: Devices and Systems at Room Temperature Operation,” Wiley 2015, ISBN: 978-1-118-92042-8

Courses

	Course nr. 18-pr-2010-vl	**Course name** Terahertz Systems and Applications		
	Instructor Prof. Dr. rer. nat. Sascha Preu		**Type** Lecture	**SWS** 2
	Course nr. 18-pr-2010-ue	**Course name** Terahertz Systems and Applications		
	Instructor Prof. Dr. rer. nat. Sascha Preu		**Type** Practice	**SWS** 1

Module name					
Modelling and Simulation of Circuits					
Module nr. 18-sc-2010	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** Prof. Dr. rer. nat. Sebastian Schöps		

1	**Teaching content** The content of this course is the following: • Circuit interpretation as directed graphs • Modified nodal and loop analysis • Flux and charge oriented formulations • Differential algebraic equations • Linear system solver • Numerical solution of nonlinear systems • Time-domain methods • Frequency-domain solution • Implementation of the numerical methods
2	**Learning objectives** Students understand the theoretical and numerical fundamentals of circuit simulation and how the equations can be derived from Maxwell's equations. Circuit properties can be expressed in tems of graph theory. The sparse systems of equations such as the flux/charge oreinted modified nodal analysis can be assembled. In order to solve the obtained systems, different numerical methods for the simulation of circuits are relevant. This includes methods for the solution of linear systems (direct and iterative solvers), root-finding algorithms for nonlinear systems and implicit time integration methods. Mathematical concepts such as stability, convergence order or complexity are known and can be employed to judge the advantages and disadvantages of the various methods. Eventually, the students are able to programm their own circuit simulator, that can return both frequency as well as time domain solutions of electric networks.
3	**Recommended prerequisites for participation** 18-hs-1070 Elektrotechnik und Informationstechnik I, 18-gt-1020 Elektrotechnik und Informationstechnik II, 20-00-0304 Allgemeine Informatik I, 04-10-0602 Statistics/Probability Theory, 04-10-0603 Scientific Computing
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 20 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, M.Sc. WI-etit, M.Sc. CE, M.Sc. iCE, B.Sc. und M.Sc. iST, B.Sc. WI-etit, M.Sc. etit - CMEE
8	**Grade bonus compliant to §25 (2)** Grade bonus of 0,4 if correctly implemented programs are submitted
9	**References**

	• L. W. Nagel, "SPICE2: A computer program to simulate semiconductor circuits", University of Berkeley, Tech. Rep., 1975. • C.-W. Ho, A. E. Ruehli, and P. A. Brennan, "The modified nodal approach to network analysis", IEEE Trans. Circ. Syst., vol. 22, no. 6, pp. 504-509, Jun. 1975. • J. Vlach, K. Singhal, Computer methods for circuit analysis and design. New York : Van Nostrand Reinold, 1983.

Courses

Course nr.	Course name		
18-sc-2010-vl	Modelling and simulation of circuits		
Instructor		**Type** Lecture	**SWS** 2

Course nr.	Course name		
18-sc-2010-ue	Modelling and simulation of circuits		
Instructor		**Type** Practice	**SWS** 1

Module name Simulation of Multiphysics Problems					
Module nr. 18-sc-2030	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr. rer. nat. Sebastian Schöps		

1	**Teaching content** The course covers multiphysical and cross-domain modeling of differential-algebraic systems, e.g. consisting of electrical, electronic, mechanical, hydraulic, thermal, control, or process-oriented components, as well as the coupling of spatially distributed and lumped or integrated components. Concepts of model analysis, simulation methods and their implementation are taught.
2	**Learning objectives** The students know the individual physical models, can combine them to multiphysical models and represent them by components. They can analyze the problems and simulate them on their own. Simulation results can be interpreted and explained. Students can assess the possibilities and limitations of multiphysics simulations.
3	**Recommended prerequisites for participation** Scientific Computing, Introduction to physical modeling
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 30 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. CE, M.Sc. etit - CMEE
8	**Grade bonus compliant to §25 (2)** Yes. An earned bonus is creditable until the exercise is offered again.
9	**References** Will be handed out during the lecture and is provided via Moodle.

Courses

Course nr.	Course name	Instructor	Type	SWS
18-sc-2030-vl	Simulation of Multiphysics Problems	Prof. Dr. rer. nat. Sebastian Schöps	Lecture	2
18-sc-2030-ue	Simulation of Multiphysics Problems	Prof. Dr. rer. nat. Sebastian Schöps	Practice	2

Module name					
Fast Boundary Element Methods for Engineers					
Module nr. 18-sc-2040	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr. rer. nat. Sebastian Schöps		

1	**Teaching content** How to solve field problems numerically on the computer? The Boundary Element Method (BEM) has developed into an important alternative to domain-oriented approaches (like Finite Elements), ever since fast implementations are available. The BEM reduces the dimensionality of the problem and can easily take into account unbounded domains. Starting from the representation formulas of Kirchhoff and Stratton-Chu boundary integral equations are derived. Next, their discretization by collocation and Galerkin methods is discussed. The resulting fully populated matrices have to be compressed for practical applications, by Fast Multipole or Adaptive Cross Approximation methods. Practical examples for application of the BEM are considered, for instance acoustic and electromagnetic scattering problems, and thermal analysis. Programming homework will be assigned, to deepen the students' understanding of the contents.
2	**Learning objectives** Students will acquire a detailed understanding of Modeling and Simulation with BEM. • Derivation: convert certain types of partial differential equations to boundary integral equations • Discretization: obtain boundary element methods from boundary integral equations • Compression: efficiently store and solve the resulting linear systems of equations • Application: solve practical field problems in engineering, in the acoustic, electromagnetic and thermal domains
3	**Recommended prerequisites for participation** Basic knowledge about numerical methods for the solution of partial differential equations (e.g., Finite Elements). Basic knowledge about modelling and simulation in an application domain (e.g., acoustic domain: wave equation; electromagnetic domain: Maxwell's equations; thermal domain: heat equation).
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 30 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. CE
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be handed out during the lecture and is provided via Moodle.
Courses	

	Course nr. 18-sc-2040-vl	**Course name** Fast Boundary Element Methods for Engineers		
	Instructor Prof. Dr. rer. nat. Sebastian Schöps, Dr. Felix Wolf		**Type** Lecture	**SWS** 2
	Course nr. 18-sc-2040-ue	**Course name** Fast Boundary Element Methods for Engineers		
	Instructor Prof. Dr. rer. nat. Sebastian Schöps, Dr. Felix Wolf		**Type** Practice	**SWS** 2

Module name Introduction to Scientific Computing in C++					
Module nr. 18-sc-2050	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr. rer. nat. Sebastian Schöps		

1 Teaching content

Students with basic programming experience will get an introduction to computational programming of numerical algorithms in C++. The first half of this course will focus on basics of the programming language C++, and highlight aspects in which the language differs from scripting languages such as Python or Matlab. Subsequently, the focus of the course will be on efficient memory management: We discuss modern best practices such as the usage of reference types and idioms like RAII ("Resource Acquisition is Initialization") rather than classical pointers ("Raw-Pointers"). During the exercises, we illustrate the effect of memory handling for numerical linear algebra applications, and introduce STL (Standard Template Library) data structures in this context.
In the second half of the lecture, the students implement more complex algorithms from different application areas using the "Eigen" library (for linear algebra) and openMP (for parallel computing). Here, the focus lies on understanding both libraries, improving the students' programming level from the first lecture half, and solving programming tasks from different areas such as stochastics, numerical solution of differential equations, and approximations.

2 Learning objectives

Students will obtain a basic understanding for the implementation of numerical algorithms in C++ including:

- Basics of C++ (Syntax, development environments, compilation, ...)
- Differences to Python / Matlab (types, classes, pointers, references, ...)
- Data types for numerical application (e.g. float, double, Unum/Posit, HDF, ...)
- Modern C++ (Templates, RAII, Lambdas, ...) according to standard >= 11
- Working with CMake and Git
- Data types of STL and „Eigen", and the development of numerical software on their basis
- Memory management, performance benchmarks, parallelization with openMP

3 Recommended prerequisites for participation

- Essentials of programming in Python / Matlab
- Mathematik I - IV, in particular: Linear algebra, numerical solution of systems of linear equations, interpolation problems, numerics of ordinary differential equations

4 Form of examination

Module exam:

- Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)

Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 30 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. etit - DT, M.Sc. WI-etit, B.Sc. und M.Sc. iST, M.Sc. etit - CMEE

8	**Grade bonus compliant to §25 (2)** Yes. An earned bonus is creditable until the exercises are offered again.
9	**References** Will be handed out during the lecture and is provided via Moodle.

Courses

Course nr.	Course name	Type	SWS
18-sc-2050-vl	Introduction to Scientific Computing in C++		
Instructor: Dr. Manuel Baumann, Dr. Felix Wolf		Lecture	2

Course nr.	Course name	Type	SWS
18-sc-2050-ue	Introduction to Scientific Computing in C++		
Instructor:		Practice	2

Module name Communication Networks II					
Module nr. 18-sm-2010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Ralf Steinmetz		

1 Teaching 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

Upon successful completion, the module provides students with an understanding of 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 prerequisites 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 exam:

- Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

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

7 Usability of the module

	M.Sc. MEC, M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, B.Sc. CE, M.Sc. MedTec, M.Sc. iCE, M.Sc. iST, B.Ed. etit
8	**Grade bonus compliant to §25 (2)** The maximum grade improvement is 1.0. For a grade improvement to be awarded, a minimum number of points (50% of the maximum achievable points) must be reached. From this minimum number, the grade improvemnet increases proportionally (from 0.0 grade improvement at the minimum number to a maximum of 1.0 grade improvement from 95% of the maximum achievable points). Above 95% of the maximum achievable points, the bonus is 1.0.
9	**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**
Dr.-Ing. Tobias Meuser, M.Sc. Christoph Gärtner, M.Sc. Pratyush Agnihotri, Prof. Dr.-Ing. Ralf Steinmetz		Lecture	3
Course nr.	**Course name**		
18-sm-2010-ue	Communication Networks II		
Instructor		**Type**	**SWS**
Dr.-Ing. Tobias Meuser, M.Sc. Christoph Gärtner, M.Sc. Pratyush Agnihotri, Prof. Dr.-Ing. Ralf Steinmetz		Practice	1

Module name Multimedia Communications Project II					
Module nr. 18-sm-2130	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Ralf Steinmetz		

1 Teaching 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
- Resource-based Learning

2 Learning objectives

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

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

3 Recommended prerequisites for participation

Keen interest to develop and explore challenging solutions and applications in cutting edge multimedia communications systems using scientific methods. Further we expect:

- Solid experience in programming Java and/or C# (C/C++).
- Solid knowledge in object oriented analysis and design.
- Basic knowledge of design patterns, refactoring and project management.
- Solid knowledge in computer communication networks is recommended.
- Lectures in “Communication Networks I” and “Communication Networks II” are recommended

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report (including submission of programming code) and/or Presentation and/or Oral examination and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.

5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. iCE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**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) • Joshua Bloch: "Effective Java - Programming Language Guide" (ISBN-13: 978-0201310054) • Erich Gamma, Richard Helm, Ralph E. Johnson: "Design Patterns: Objects of Reusable Object Oriented Software" (ISBN 0-201-63361-2) • Martin Fowler: "Refactorings - Improving the Design of Existing Code" (ISBN-13: 978-0201485677) • Kent Beck: "Extreme Programming Explained - Embrace Changes" (ISBN-13: 978-0321278654)

Courses

Course nr.	Course name		
18-sm-2130-pr	Multimedia Communications Project Lab		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing. Julian Zobel, M.Sc. Fridolin Siegmund, Prof. Dr.-Ing. Ralf Steinmetz		Lab	6

Module name Software Defined Networking					
Module nr. 18-sm-2280	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr.-Ing. Ralf Steinmetz		

1	**Teaching content** The course deals with topics in the area of software defined networking: • SDN Data Plane • SDN Control Plane • SDN Application Plane • Network Function Virtualization • Network Virtualization and Slicing • QoS and QoE in Software Defined Networks
2	**Learning objectives** Upon completion of the module, students will have gained in-depth insights into Software Defined Networking, as well as basic technologies and applications.
3	**Recommended prerequisites for participation** Basic courses of the first 4 semesters are required. Knowledge of lectures Communication Networks I and II are recommended.
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 15 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, B.Sc. CE, M.Sc. iCE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Textbooks as indicated. Slides and paper copies as necessary.

Courses

Course nr.	**Course name**		
18-sm-2280-vl	Software Defined Networking		
Instructor		**Type**	**SWS**
Dr.-Ing. Ralf Kundel, M.Ed. Benjamin Becker, M.Sc. Chengbo Zhou		Lecture	2

	Course nr.	Course name		
	18-sm-2280-ue	Software Defined Networking		
	Instructor		**Type**	**SWS**
	Dr.-Ing. Ralf Kundel, M.Ed. Benjamin Becker, M.Sc. Chengbo Zhou		Practice	2

Module name Transport Protocols and their Design					
Module nr. 18-sm-2320	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Irregular
Language German			**Module owner** Prof. Dr. rer. nat. Björn Scheuermann		

1	**Teaching content** This module covers in-depth knowlege about transport protocols and related aspects. We will consider robustness, ease of implementation, efficiency, performance and reliability. Of particular interest will be how to model the protocol behavior and the interplay of transport protocols with other layers of the Internet protocol stack. The focus will be on the Transmission Control Protocol (TCP) and its variants.
2	**Learning objectives** After taking this module, students understand the protocol mechanisms of the transport layer in detail, including their interplay within the layer and with other protocol layers. They can use this knowledge to predict and evaluate the effects of protocol modifications. To this end, they are able to analyze the behavior of transport protocols and to assess the impact of key parameters including latency, bandwidth and buffer size on the suitability of different design variants.
3	**Recommended prerequisites for participation** Basic knowledge in the field of communication networks, as covered for instance in the module „Kommunikationsnetze 1".
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS) The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 30 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	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, B.Sc. CE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)** Yes
9	**References** Technical literature will be mentioned in the lecture.

Courses

Course nr.	**Course name**		
18-sm-2320-vl	Transport Protocols and their Design		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Björn Scheuermann		Lecture	3

Course nr.	**Course name**		
18-sm-2320-ue	Transport Protocols and their Design		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Björn Scheuermann		Practice	2

Module name					
Application-Layer Protocols on the Internet					
Module nr. 18-sm-2330	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Irregular
Language German			**Module owner** Prof. Dr. rer. nat. Björn Scheuermann		

1	**Teaching content** The module covers in-depth knowledge on application architectures and application-layer protocols used on the Internet. This includes widely used client-server protocols like HTTP as well as distributed architectures (peer-to-peer systems, blockchains, etc.). The focus is on tradeoffs between design alternatives and the acquisition of the skills to design and implement efficient and effective protocols on the application layer.
2	**Learning objectives** After taking this module, students understand the key questions that the design of an application-layer protocols poses. They understand the design space and are able to recognize and avoid common problems and mistakes. They can apply this knowledge to design and analyze protocol designs, and they are able to design suitable protocol mechanisms for practically relevant design problems.
3	**Recommended prerequisites for participation** Basic knowledge in the field of communication networks, as covered for instance in the module „Communication Networks I".
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS) The examination takes place in form of an oral examination (duration: 30 minutes). If one can estimate that more than 30 students register, the examination will be a written exam (duration: 120 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, B.Sc. CE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)** Announcements will be made at the beginning of the semester as to whether there will be homework assignments to accompany the lecture that will improve grades.
9	**References** Technical literature will be mentioned in the course.

Courses

Course nr.	Course name	Instructor	Type	SWS
18-sm-2330-vl	Application-Layer Protocols on the Internet	Prof. Dr. rer. nat. Björn Scheuermann	Lecture	3
18-sm-2330-ue	Application-Layer Protocols on the Internet	Prof. Dr. rer. nat. Björn Scheuermann	Practice	2

Module name Resilient Communication Networks					
Module nr. 18-sm-2340	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr. rer. nat. Björn Scheuermann		

1	**Teaching content**
	The course covers the following topics:
	• Resilience in the different disciplines
	• Resilience in communication networks
	• Importance of resilience for communication networks
	• Requirements for current communication networks
	• Methods to increase resilience in communiation networks
	  – Wireless networks (e.g., mobile communications)
	  – Wired networks
	• Resilient network management in software-defined networks
	• Resilience through adaptivity in software-defined networks

2	**Learning objectives** Students are familiar with the idea and necessity of resilience in various disciplines with a focus on adaptive communication networks. They are familiar with various methods for increasing resilience, such as redundancy and diversity, and can apply these methods to the design of communication networks.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 min.). If one can estimate that less than 10 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	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, B.Sc. CE, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)** Grade improvements up to 0.4 according to APB 25(2) through bonus for regularly completed and submitted bonus exercises.
9	**References**

A lecture notes or slides can be downloaded:

- Moodle Platform

Advanced literature

- Smith, Paul, et al. "Network resilience: a systematic approach." IEEE Communications Magazine 49.7 (2011): 88-97
- Sterbenz, James PG, et al. "Resilience and survivability in communication networks: Strategies, principles, and survey of disciplines." Computer networks 54.8 (2010): 1245-1265
- Mauthe, Andreas, et. al. "Disaster-resilient communication networks: Principles and best practices." 2016 8th International Workshop on Resilient Networks Design and Modeling (RNDM). IEEE, 2016

Courses

Course nr.	**Course name**		
18-sm-2340-vl	Resilient Communication Networks		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Björn Scheuermann, Dr.-Ing. Tobias Meuser		Lecture	2
Course nr.	**Course name**		
18-sm-2340-ue	Resilient Communication Networks		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Björn Scheuermann, Dr.-Ing. Tobias Meuser		Practice	1

Module name Routing, Switching and Forwarding					
Module nr. 18-sm-2350	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Irregular
Language German			**Module owner** Prof. Dr. rer. nat. Björn Scheuermann		

1	**Teaching content** The Modul covers in-depth knowledge about the network layer and related aspects of the link layer. For different types of networks and different requirements we consider methods for routing, for the representation of routing and switching data and for packet forwarding. The focus is on questions of protocol design with respect to robustness, stability and efficiency, also in terms of the interplay with other layers. Security aspects of the network layer are also considered, for instance firewall technologies or BGP security. The accompanying exercises in part consist of group exercise lab blocks.
2	**Learning objectives** After taking this module, students understand the design options for routing in networks and the efficient implementation of packet forwarding in detail. They can use this knowledge to assess the effects of protocol design decisions and to analyze the expected and actual behavior of protocol designs, individually and in comparison.
3	**Recommended prerequisites for participation** Basic knowledge in the field of communication networks, as covered for instance in the module „Communication Networks I".
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS) The examination is an oral examination (duration: 30 min.). If it is foreseeable that more than 30 students will enroll, the examination can also take the form of a written exam (duration: 120 min.). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, B.Sc. CE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)** Announcements will be made at the beginning of the semester as to whether there will be homework assignments to accompany the lecture that will improve grades.
9	**References** Technical literature will be mentioned in the course.

Courses

Course nr.	**Course name**		
18-sm-2350-vl	Routing, Switching and Forwarding		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Björn Scheuermann		Lecture	3

	Course nr.	Course name		
	18-sm-2350-ue	Routing, Switching and Forwarding		
	Instructor		**Type**	**SWS**
	Prof. Dr. rer. nat. Björn Scheuermann		Practice	2

Module name					
Energy Management and Optimization					
Module nr. 18-st-2010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1	**Teaching content** The lecture reviews the different levels of energy management. It then focuses on economic dispatch and discusses its different use cases like optimization of self-consumption, virtual power plants, electric vehicle load management or multi-modal neighborhood optimization. Relevant knowledge about the components to be controlled as well as the markets to be addressed is explained. After this introduction to economic dispatch‘s application environment, the lecture focuses on the methods employed. The underlying mathematical formulations as different types of optimization problems (LP, MILP, QP, stochastic optimization) are reviewed. In parallel, a practical introduction to numerical optimization is given (descent algorithms, convergence, convexity, programming languages for the formulation of optimization problems). Moreover, an introduction into simple methods for the prognosis of future values (linear regression) is provided. All methodological learning is accompanied by hands-on exercises using Python and the mathematical modeling language GAMS.
2	**Learning objectives** Students know the different use cases and formulations of economic dispatch. They have a basic understanding of the typically employed optimization methods and are able to judge the quality of the achieved results. Moreover, students are independently able to formulate (energy) optimization problems and solve them with Python and GAMS.
3	**Recommended prerequisites for participation** Standard knowledge of linear algebra and multivariate analysis as well as basic knowledge in the use of Python is required. Knowledge of the modules „Kraftwerke & EE“ or „Energiewirtschaft“ is helpful but not necessary.
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 8 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE, B.Ed. etit, B.Sc. und M.Sc. iST, B.Sc. WI-etit, M.Sc. etit - CMEE
8	**Grade bonus compliant to §25 (2)** Improvement of grades up to 0.4 compliant to APB 25(2) through bonus system for re-gular attention of exercises and practical courses
9	**References**

- Boyd, Vandenberghe: Convex Optimization, Cambridge University Press, 2004
- A GAMS Tutorial by Richard E. Rosenthal
  https://www.gams.com/24.8/docs/userguides/userguide/_u_g__tutorial.html

Courses

Course nr.	Course name	Instructor	Type	SWS
18-st-2010-vl	Energy Management and Optimization	Prof. Dr. rer. nat. Florian Steinke, M.Sc. Sina Hajikazemi	Lecture	2
18-st-2010-ue	Energy Management and Optimization	Prof. Dr. rer. nat. Florian Steinke, M.Sc. Sina Hajikazemi	Practice	1
18-st-2010-pr	Energy Management and Optimization Lab	Prof. Dr. rer. nat. Florian Steinke, M.Sc. Sina Hajikazemi	Lab	1

Module name Machine Learning & Energy					
Module nr. 18-st-2020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1	**Teaching content** The analysis and interpretation of data becomes ever more important, also for engineers. Digitalization and Smart Grids are terms to describe a host of novel data-based services in the field of generation, distribution, consumption, and marketing of (renewable) energy. The lecture presents the recent developments and their underlying machine learning methods. For a start we describe the different problem settings of machine learning methods, review recent developments in the field, and evaluate the impact of machine learning on the energy sector. After such an introductory overview, we review the basics of linear algebra and numerical optimization. We then introduce supervised learning problems and study different model classes to solve such problems (linear models, trees, random forests, nearest neighbor, kernel methods, deep learning). We then turn to a probabilistic view and study unsupervised learning problems. Finally, we give an introduction to probabilistic graphical models. Throughout the semester we discuss exemplary applications of machine learning in the energy domain (e.g. renewable forecasting, predictive maintenance, state estimation, probabilistic load flow). Practical exercises with Python deepen the understanding and support students' actively usable skills.
2	**Learning objectives** Students understand important machine learning problem settings andsome key methods for each task. They know common applications thereof in the energy domain. Moreover, the students are able to apply and adapt those methods independently to new applications (not only from the energy domain).
3	**Recommended prerequisites for participation** • Good knowledge of linear algebra required • Basic knowledge of statistics and numerical optimization will be helpful • Using Python for programming the practical examples should pose no difficulty
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 8 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. CE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)** Notenverbesserungen bis zu 0,4 nach APB 25(2) durch Bonus für regelmäßig besuchte Übungs-/Praktikumstermine und mindestens einmaliges Vorrechnen in den Übungen
9	**References**

- K.P. Murphy: Machine Learning. A Probabilistic Perspective.
- C.M. Bishop: Pattern Recognition & Machine Learning
- J. Friedman, T. Hastie, R. Tibshirani: The elements of statistical learning
- D. Koller, N. Friedmann: Probabilistic Graphical Models. Principles and Techniques

Courses

Course nr.	Course name	Instructor	Type	SWS
18-st-2020-vl	Machine Learning & Energy	Prof. Dr. rer. nat. Florian Steinke, M.Sc. Benedikt Grüger, M.Sc. Andrei Eliseev	Lecture	2
18-st-2020-ue	Machine Learning & Energy	Prof. Dr. rer. nat. Florian Steinke, M.Sc. Benedikt Grüger, M.Sc. Andrei Eliseev	Practice	1
18-st-2020-pr	Machine Learning & Energy Lab	Prof. Dr. rer. nat. Florian Steinke, M.Sc. Benedikt Grüger, M.Sc. Andrei Eliseev	Lab	1

Module name					
Technology and Economics of Multimodal Energy Systems					
Module nr. 18-st-2060	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** Prof. Dr.-Ing. Stefan Nießen		

1	**Teaching content** Energy economical framework, structures of multimodal energy systems, investment and costing, energy trading, sources for flexibility including storage, regulation, sustainability, social acceptance and stakeholder interests Topics of good scientific practice, as well as societal or ethical aspects of product design, optimization, and algorithms are addressed in an accompanying manner, where technically appropriate.
2	**Learning objectives** The students learn the structures of energy supply systems including electricity, primary energies, heating, cooling, transport and water desalination. They understand the underlying principles for the design of energy systems for buildings, sites, cities and countries and are able to assess their adequacy for different international locations considering costs, environmental impact and social acceptance. The students learn to assess the economic viability of investments in energy asssets using new present value and annuity. They learn the functionning of energy markets and different forms of trading and settlement for energy transactions. Based on an analysis of the impact of an increasing share of renewables in the system, the students learn the technology of different sources for flexbility including demand-side-management, different technologies for storage and for the coupling of different modes of energy. Storage technologies include batteries, pumped hydro, hydrogen and inertia. Multimodal coupling technologies include power-heat, heat-cooling, power-heat-water and industrial processes. Energy systems are subject to numerous laws and regulations. Therefore, the students learn different elements that define the regulatory framework such as feed-in tarifs, tax incentives, credit programs, quotas and certificates. The regulations are the result of societal processes. Therefore, the students analyze the different interest groups, origins and impact of public opinion and the perception of risk.
3	**Recommended prerequisites for participation** A completed Bachelor in any of the following subjects: electrical engineering, mechanical engi-neering, mechatronics, environmental sciences, business administration/engineering (Wirtschaftsingenieurwesen)
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS) In general, the module is examined by written examination (duration: 120 min.). If 20 students or less apply, the exam is oral (duration: 30 min.). The mode of examination will be communicated within one working week after the end of the exam application phase.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)** Grade improvement of 0.4 by successful presentation during the seminar
9	**References**

- Downloadable slides
- Book.energytransition.org/en
- https://www.agora-energiewende.de/fileadmin2/Projekte/2018/A_word_on/Agora_Energiewende_a-word-on_flexibility_WEB.pdf

Courses

Course nr.	Course name		
18-st-2060-vl	Technology and Economics of Multimodal Energy Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Stefan Nießen		Lecture	2
Course nr.	**Course name**		
18-st-2060-se	Technology and Economics of Multimodal Energy Systems - simulation game		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Stefan Nießen		Seminar	1

Module name Designing the Energiewende					
Module nr. 18-st-2080	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Stefan Nießen		

1	**Teaching content** Current studies on the energy transition will be analyzed and discussed. Based on a computer simulation (simulation game energy transition), interdisciplinary teams will have to make independent decisions on the political-legal framework, the expansion of the energy system and its operation. In fast motion from 2020 to 2050, the consequences of the decisions for CO2 balance, costs and security of supply will be experienced. For this purpose, the roles of electricity producers, industry, private households and politics will be assumed. Topics of good scientific practice, as well as social or ethical aspects of product design, optimization and algorithms will be addressed where technically appropriate.
2	**Learning objectives** The students know different methods for techo-economical analysis of energy systems and base parameters of energy systems. Furthermore they have an overview on main technologies for energy conversion and storage today and possible future evolutions. They also comprehend governance basics consisting in EU legal acts, German laws and directives and an overview on the institutions implementing these.
3	**Recommended prerequisites for participation** A completed Bachelor in any of the following subjects: electrical engineering, mechanical engineering, mechatronics, environmental sciences, business administration/electrical engineering (Wirtschaftsingenieurwesen-Elektrotechnik und Informationstechnik), Political Sciences
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** • Downloadable slides • Book.energytransition.org/en • https://www.agora-energiewende.de/fileadmin2/Projekte/2018/A_word_on/Agora_Energiewende_a-word-on_flexibility_WEB.pdf
Courses	

	Course nr. 18-st-2080-vl	**Course name** Designing the Energiewende - lecture		
	Instructor Prof. Dr. rer. nat. Florian Steinke, Prof. Dr. phil. Michèle Knodt, Prof. Dr.-Ing. Stefan Nießen		**Type** Lecture	**SWS** 1
	Course nr. 18-st-2080-pr	**Course name** Designing the Energiewende - serious game		
	Instructor Prof. Dr. rer. nat. Florian Steinke, Prof. Dr. phil. Michèle Knodt, Prof. Dr.-Ing. Stefan Nießen		**Type** Lab	**SWS** 1
	Course nr. 18-st-2080-se	**Course name** Designing the Energiewende - seminar		
	Instructor Prof. Dr. rer. nat. Florian Steinke, Prof. Dr. phil. Michèle Knodt, Prof. Dr.-Ing. Stefan Nießen		**Type** Seminar	**SWS** 1

Module name					
Software-Engineering - Maintenance and Quality Assurance					
Module nr. 18-su-2010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1	**Teaching 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, the participants analyze, test and restructure different examples.
2	**Learning objectives** The lecture uses a single running example to teach basic software maintenance and quality assuring techniques in a practice-oriented style. Upon successful completion of the module, students 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 play a major role.
3	**Recommended prerequisites for participation** Introduction to Computer Science for Engineers as well as basic knowledge of Java
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, B.Sc. CE, M.Sc. MedTec, M.Sc. iST, M.Sc. etit - CMEE
8	**Grade bonus compliant to §25 (2)**
9	**References** https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/se-ii-v and Moodle

Courses

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

Module name Real-Time Systems					
Module nr. 18-su-2020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1	**Teaching content** The lecture basically covers a model-driven software engineering process which is specially customized for real-time systems. This process is more deeply explored in the exercise using an automotive example. A focus is laid on object-oriented techniques. In this context, a real-time specific state-of-the-art CASE tool is introduced and used. Furthermore, fundamental characteristics of real-time systems and system architectures are introduced. Scheduling algorithms are discussed to get insights into real-time operating systems. Finally, a comparison between the Java programming language and its expansion for real-time operating systems (RT Java) will conclude the lecture.
2	**Learning objectives** After successful completion of the module, students are able to use and evaluate model-based (object-oriented) techniques for the development of embedded real-time systems. This includes a deeper understanding of the following topics: • classification of real-time systems • create and analyze executable models • application of real-time scheduling algorithms • evaluation and comparison of pros/cons of real-time programming languages as well as real-time operating systems
3	**Recommended prerequisites for participation** Basic knowledge of software engineering techniques and excellent knowledge of at least one object-oriented programming language (preferably Java)
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 15 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	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, B.Sc. CE, M.Sc. iCE, M.Sc. iST, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)** Grade improvements up to 0.4 per APB 25 (2) due to bonus for regularly submitted homework tasks
9	**References** https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/es-v and Moodle
Courses	

	Course nr.	Course name		
	18-su-2020-vl	Real-Time Systems		
	Instructor		**Type**	**SWS**
	Prof. Dr. rer. nat. Andreas Schürr		Lecture	3
	Course nr.	**Course name**		
	18-su-2020-ue	Real-Time Systems		
	Instructor		**Type**	**SWS**
	M.Sc. Hendrik Göttmann, Prof. Dr. rer. nat. Andreas Schürr		Practice	1

Module name Adaptive Filters					
Module nr. 18-zo-2010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir		

1 Teaching content

Theory:

1. Derivation of optimal filters for stochastic processes, e.g. Wiener filter or linear prediction filter based on suitable cost functions.
2. Elaboration of adaptive procedures, which allow to iteratively approach the optimal solution for non-stationary signals in non-stationary environments. Here, the adaptive procedures such as NLMS adaptation, affine projection, and the RLS algorithm are derived and extensively analysed.
3. Analysis of the adaptation behaviour and control procedures of adaptive filters based on the NLMS procedure.
4. Derivation and analysis of the Kalman filter as optimal filter for non-stationary input signals.
5. Procedures for the decomposition of signals into sub-bands for the realization of optimal filters in the frequency domain, e.g. noise reduction procedures.

Applications:
Parallel to the theory, practical applications are explained. As an example for the Weiner filter, the acoustic noise reduction procedures are explained. Acoustic echo cancellation and feedback cancellation are given as examples for adaptive filters. Furthermore beamforming approaches are introduced.

It is planned to offer an excursion to Siemens Audiology Engineering Group in Erlangen.
In the 4 to 5 exercises, some content of the lecture will be implemented in MATLAB which allows the students to get familiar with practical realizations of the theoretical procedures.

2 Learning objectives

Upon completion of the module, students were taught the fundamentals of adaptive filters. The necessary algorithms are derived, interpreted and applied to examples of speech, audio and video processing. Based on the content of the lecture you are able to apply adaptive filters to real practical applications.
For the admission to the exam you give a talk about a topic in the domain of adaptive filters chosen by you. This will allow you to acquire the know-how to read and understand scientific literature, familiarize yourself 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 prerequisites for participation

Digital Signal Processing

4 Form of examination

Module exam:
- Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)

The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 21 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

	M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**References** Slides of the lecture. Literature: • E. Hänsler, G. Schmidt: Acoustic Echo and Noise Control, Wiley, 2004 (Textbook of this course); • S. Haykin: Adaptive Filter Theory, Prentice Hall, 2002; • A. Sayed: Fundamentals of Adaptive Filtering, Wiley, 2004; • P. Vary, U. Heute, W. Hess: Digitale Sprachsignalverarbeitung, Teubner, 1998 (in German)

Courses

Course nr.	Course name		
18-zo-2010-vl	Adaptive Filters		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Henning Puder		Lecture	3
Course nr.	**Course name**		
18-zo-2010-ue	Adaptive Filters		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Henning Puder		Practice	1

Module name					
Module name Digital Signal Processing					
Module nr. 18-zo-2060	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir		

1	**Teaching 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** Students understand basic principles of signal processing. They can design and analyze FIR and IIR filters. Furthermore, they are able to analyze statistical signals in the time and frequency domain. The students know the basics of spectral estimation and can design non-parametric as well as parametric spectral estimators and analyze them with respect to their performance.
3	**Recommended prerequisites for participation** Deterministic signals and systems theory
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 180 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. MedTec, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**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.	Course name		
18-zo-2060-vl	Digital Signal Processing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Abdelhak Zoubir, M.Sc. Christian Schroth, M.Sc. Christian Eckrich		Lecture	3

	Course nr.	Course name		
	18-zo-2060-ue	Digital Signal Processing		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Abdelhak Zoubir, M.Sc. Christian Schroth, M.Sc. Christian Eckrich		Practice	1

Module name Speech and Audio Signal Processing					
Module nr. 18-zo-2070	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir		

1	**Teaching 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** Based on the module 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 prerequisites for participation** Knowlegde about satistical signal processing (lecture „Digital Signal Processing“). Desired - but not mandatory - is knowledge about adaptive filters.
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) 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	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. MedTec, M.Sc. iCE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Slides (for further details see homepage of the lecture)
Courses	

	Course nr. 18-zo-2070-vl	**Course name** Speech and Audio Signal Processing		
	Instructor Prof. Dr.-Ing. Henning Puder		**Type** Lecture	**SWS** 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** Sprach- und Audiosignalverareitung		
	Instructor Prof. Dr.-Ing. Henning Puder		**Type** Seminar	**SWS** 1

Module name Data Science I					
Module nr. 18-zo-2110	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir		

1 Teaching content

The course covers the following topics:

- Python programming basics
- Data science introduction
- Data storage and formats
- Data exploration and visualization
- Statistical methods and inference
  - Descriptive statistics (uni & bivariate)
  - Inferential statistics
- Feature extraction
  - Time Series Data
  - Image data
  - Audio data
- Statistical learning
  - Cross-validation, overfitting, annotation
  - Regression
  - Classification

2 Learning objectives

This module offers an introduction to the topic of Data Science with a strong practical orientation. Students gain knowledge about all parts of a Data Science processing: From storage/data acquisition over inferential statistics to visualization.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)

The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 16 students register, the examination will be an oral examination (duration: 45 min.). The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS

8 Grade bonus compliant to §25 (2)

Yes

9 References

- Lecture notes and slides can be downloaded here:
  - http://www.spg.tu-darmstadt.de
  - moodle
- Further reading:
  - Wes McKinney: Python for Data Analysis, O'Reilly, 2017
  - Christopher M. Bishop: Pattern Recognition and Machine Learning, 2011
  - James, Witten, Hastie and Tibshirani, Introduction to Statistical Learning, Springer, 2017

Courses

Course nr.	Course name		
18-zo-2110-vl	Data Science I		
Instructor		**Type**	**SWS**
Dr.-Ing. Christian Debes		Lecture	2
Course nr.	**Course name**		
18-zo-2110-ue	Data Science I		
Instructor		**Type**	**SWS**
Dr.-Ing. Christian Debes		Practice	2

Module name Resilient Communication Networks					
Module nr. 18-sm-2340	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr. rer. nat. Björn Scheuermann		

1	**Teaching content**
	The course covers the following topics:
	• Resilience in the different disciplines
	• Resilience in communication networks
	• Importance of resilience for communication networks
	• Requirements for current communication networks
	• Methods to increase resilience in communiation networks
	  – Wireless networks (e.g., mobile communications)
	  – Wired networks
	• Resilient network management in software-defined networks
	• Resilience through adaptivity in software-defined networks

2	**Learning objectives** Students are familiar with the idea and necessity of resilience in various disciplines with a focus on adaptive communication networks. They are familiar with various methods for increasing resilience, such as redundancy and diversity, and can apply these methods to the design of communication networks.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 min.). If one can estimate that less than 10 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	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, B.Sc. CE, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)** Grade improvements up to 0.4 according to APB 25(2) through bonus for regularly completed and submitted bonus exercises.
9	**References**

A lecture notes or slides can be downloaded:

- Moodle Platform

Advanced literature

- Smith, Paul, et al. "Network resilience: a systematic approach." IEEE Communications Magazine 49.7 (2011): 88-97
- Sterbenz, James PG, et al. "Resilience and survivability in communication networks: Strategies, principles, and survey of disciplines." Computer networks 54.8 (2010): 1245-1265
- Mauthe, Andreas, et. al. "Disaster-resilient communication networks: Principles and best practices." 2016 8th International Workshop on Resilient Networks Design and Modeling (RNDM). IEEE, 2016

Courses

Course nr.	**Course name**		
18-sm-2340-vl	Resilient Communication Networks		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Björn Scheuermann, Dr.-Ing. Tobias Meuser		Lecture	2

Course nr.	**Course name**		
18-sm-2340-ue	Resilient Communication Networks		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Björn Scheuermann, Dr.-Ing. Tobias Meuser		Practice	1

Module name Hardware for Neural Networks					
Module nr. 18-zh-2010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Li Zhang		

1	**Teaching content** • Training and inference of neural networks • Challenges in accelerating neural networks • Computation cost reduction in neural networks • Neural networks acceleration with logic design and FPGAs • Neural networks acceleration with in-memory-computing platforms
2	**Learning objectives** Students that have completed this module know the development of neural networks and the challenges in accelerating neural networks with CPUs and GPUs. They can evaluate the computation cost of neural networks and select the corresponding methods to reduce the computation cost. They are also enabled to evaluate the performance of the different hardware acceleration platforms for neural networks.
3	**Recommended prerequisites for participation** Basic programming skills in Python.
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. etit - AUT, M.Sc. iCE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Slides can be downloaded through Moodle platform.

Courses

Course nr.	Course name	Instructor	Type	SWS
18-zh-2010-vl	Hardware for Neural Networks	Prof. Dr.-Ing. Li Zhang	Lecture	2
18-zh-2010-pr	Hardware for Neural Networks	Prof. Dr.-Ing. Li Zhang	Lab	2

Module name Nanoelectronics					
Module nr. 18-me-2040	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr. rer. nat. Markus Meinert		

1	**Teaching content** The lecture gives an overview of the technologies of nanoelectronics: • Fabrication of devices on the nanometer scale • Nanomaterials: quantum dots, nanowires, 2D materials (e.g. graphene) • Quantum Metrology Triangle (single-electron transistor, quantum Hall effect, Josephson effect) • FinFET transistors and other nanoscale devices
2	**Learning objectives** The students will know the basics of fabrication and application of electronic devices on the nanometer scale. They can describe the operating principles of modern nano-devices and understand the precise measurement of current, voltage, and resistance via quantum mechanical effects and physical constants. Within the seminar, the students give a presentation on a nanoelectronic method or device of their choice. Thereby, they gain the ability to conduct self-directed literature research and to give technical presentations.
3	**Recommended prerequisites for participation** Basic knowledge of semiconductors
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 10 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. Seminar presentation about a subject of Nanoelectronics, individual (15 to 20 minutes) or as teams of two (25 to 30 minutes).
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. iCE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** • Lecture slides will be made available electronically • Further literature will be announced during the lecture

Courses

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-me-2040-vl</td><td colspan="3">Course name
Nanoelectronics</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. rer. nat. Markus Meinert</td><td>Type
Lecture</td><td>SWS
2</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-me-2040-se</td><td colspan="3">Course name
Nanoelectronics</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. rer. nat. Markus Meinert</td><td>Type
Seminar</td><td>SWS
1</td></tr>
</table>

2.2 Labs

<table>
<tr><td colspan="6">Module name
Laboratory Control Engineering II</td></tr>
<tr><td>Module nr.
18-ad-2060</td><td>Credit points
5 CP</td><td>Workload
150 h</td><td>Self-study
90 h</td><td>Module duration
1 Term</td><td>Module cycle
Winter term</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr.-Ing. Jürgen Adamy</td></tr>
</table>

1	**Teaching content** During the laboratory course the following experiments will be conducted: Coupling control of a helicopter, Non-linear control of a gyroscope, Nonlinear multivariable control of an aircraft, Servo control systems, Control of an overhead crane system, Programmable logic control of a stirring process
2	**Learning objectives** After attending this module, a student is capable of: 1. recalling the basics of the conducted experiments, 2. organize and comprehend background information for experiments, 3. assemble experimental set-ups based on manuals, 4. judge the relevance of experimental results by comparing them with theoretically predicted outcomes, 5. present the results of the experiments
3	**Recommended prerequisites for participation** System Dynamics and Control Systems II, the attendance of the additional lecture “System Dynamics and Control Systems III” is recommended
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - AUT, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**References** Adamy: Instruction manuals for the experiments (available during the kick-off meeting)

Courses

<table>
<tr><td>Course nr.
18-ad-2060-pr</td><td colspan="2">Course name
Laboratory Control Engineering II</td></tr>
<tr><td>Instructor
M.Sc. Nikolas Hohmann, Prof. Dr.-Ing. Jürgen Adamy</td><td>Type
Lab</td><td>SWS
4</td></tr>
</table>

<table>
<tr><td colspan="7">Module name
Power Laboratory I</td></tr>
<tr><td colspan="2">Module nr.
18-bt-2091</td><td>Credit points
5 CP</td><td>Workload
150 h</td><td>Self-study
105 h</td><td>Module duration
1 Term</td><td>Module cycle
Winter term</td></tr>
<tr><td colspan="4">Language
German/English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Yves Burkhardt</td></tr>
<tr><td>1</td><td colspan="6">Teaching content
Safety instructions for laboratory; Topic of experiments:
• Electrical energy conversion
• Power electronics
• High voltage technology
• Electrical energy supply
• Renewable energies</td></tr>
<tr><td>2</td><td colspan="6">Learning objectives
After completion of the module, the students have learned to work practically in small groups on tasks from electrical power engineering.</td></tr>
<tr><td>3</td><td colspan="6">Recommended prerequisites for participation
Power Engineering or similar</td></tr>
<tr><td>4</td><td colspan="6">Form of examination
Module exam:
• Module exam (Study achievement, Oral/written examination, Default RS)
Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.</td></tr>
<tr><td>5</td><td colspan="6">Prerequisite for the award of credit points
Passing the final module examination</td></tr>
<tr><td>6</td><td colspan="6">Grading
Module exam:
• Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td colspan="6">Usability of the module
M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE, B.Sc. und M.Sc. iST</td></tr>
<tr><td>8</td><td colspan="6">Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td colspan="6">References
• A. Binder et al.: Textbook with detailed description of experiments;
• A. Binder et al.: Skript zur Lehrveranstaltung mit Versuchsanleitungen;
• J. Hindmarsh: Electrical Machines and their Application, Pergamon Press, 1991
• S. A. Nasar, C. Trutt: Electric Power systems, Taylor & Francis, 1998
• N. Mohan et al.: Power Electronics, Converters, Applications and Design, Wiley, 2002
• D. Kind, H. Kärner: High-Voltage Insulation Technology, Vieweg & Teubner, 1985</td></tr>
<tr><td colspan="7">Courses</td></tr>
</table>

	Course nr. 18-bt-2091-pr	**Course name** Power Laboratory I		
	Instructor Prof. Dr.-Ing. Yves Burkhardt		**Type** Lab	**SWS** 3
	Course nr. 18-bt-2090-tt	**Course name** Laboratory Briefing		
	Instructor Dr.-Ing. Björn Deusinger, Prof. Dr.-Ing. Yves Burkhardt		**Type** Tutorial	**SWS** 0

Module name Power Laboratory II					
Module nr. 18-bt-2092	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** Prof. Dr.-Ing. Yves Burkhardt		

1	**Teaching content** Practical course on power engineering - Distribution and Application. About 50% of the units are devoted to power distribution and high voltage engineering; About 50% are dealing with application in drive systems, concerning "field-oriented control" of variable speed drives, encoder sytems
2	**Learning objectives** After completion of the module, the students have learned to work in small groups on in-depth tasks from electrical power engineering in a practical and independent manner.
3	**Recommended prerequisites for participation** Power Engineering or similar
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Text book with detailed laboratory instructions

Courses

Course nr.	**Course name**	**Instructor**	**Type**	**SWS**
18-bt-2092-pr	Power Laboratory II	Prof. Dr.-Ing. Yves Burkhardt	Lab	3
18-bt-2090-tt	Laboratory Briefing	Dr.-Ing. Björn Deusinger, Prof. Dr.-Ing. Yves Burkhardt	Tutorial	0

Module name Practical Training with Drives					
Module nr. 18-bt-2100	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Yves Burkhardt		

1	**Teaching content** The purpose of this laboratory is gaining extented knowledge about realization and behaviour of drive systems. An introduction in measurement problems concerning drives is given. The contents of the laboratory is setting drives to work and investigating drive systems under laboratory conditions. Special attention is paid to inverter-fed AC drives. The laboratory experiments are individually coordinated with the previous knowledge of the respective courses (ETiT or MEC).
2	**Learning objectives** The students get the ability of measurement for electrical motors, generators and transformers.
3	**Recommended prerequisites for participation** Bachelor of Science in Electrical Engineering, Power Engineering or similar
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Textbook with lab instructions • W. Nürnberg: Die Prüfung elektrischer Maschinen, Springer, 2000 • P. Brosch: Moderne Stromrichterantriebe, Kamprath-Reihe, Vogel-Verlag, 1998 • Textbook - A. Binder: Motor Development for Electrical Drive Systems • Textbook - G. Griepentrog: Control of Drives

Courses

Course nr.	**Course name**		
18-bt-2100-pr	Practical Training with Drives		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Yves Burkhardt		Lab	3

	Course nr.	Course name		
	18-bt-2090-tt	Laboratory Briefing		
	Instructor		**Type**	**SWS**
	Dr.-Ing. Björn Deusinger, Prof. Dr.-Ing. Yves Burkhardt		Tutorial	0

Module name Serious Games Lab					
Module nr. 18-de-2060	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** PD Dr.-Ing. Stefan Göbel		

1	**Teaching content** In this lab the students will design concepts and implement prototypes in the field of serious games (e.g. in education, health and sports). The topics relate to current research questions in the field, partly in cooperation with partners from the games industry and/or Serious Games users.
2	**Learning objectives** After successfully attending the course, the students can conceptualize and prototypically implement practical tasks in the context of “Serious Games”. Besides, the students are able to present their findings in front of an audience applying a number of different presentation techniques and to actively participate in a scientific discussion on their topic.
3	**Recommended prerequisites for participation** Programming skills (depending on topic).
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report (including submission of programming code) and/or Presentation and/or Oral examination and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. CE, B.Sc. CE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
18-de-2060-pr	Serious Games Lab		
Instructor		**Type**	**SWS**
PD Dr.-Ing. Stefan Göbel		Lab	4

Module name					
Network and Cyber-physical Systems Lab					
Module nr. 18-fi-2050	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr.-Ing. Rolf Findeisen		

1	**Teaching content** Based on different laboratory test benches and simulation studies the students will apply controller designs for network interconnected cyber-physical systems, spanning from mobile-robots, drones, to complex automation systems. The main goal is to apply design approaches and analyze the impact of interconnection and communication effects.
2	**Learning objectives** After this lab the students will understand the challenges of controlling interconnected systems and systems controlled via a communication network. They will be able to analyse network and cyber-physical systems and design and apply different controller design approaches and make them work on a laboratory experiment.
3	**Recommended prerequisites for participation** Fundamental knowledge of basic control and the analysis and control of interconnected cyber-physical systems.
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture notes for the lab tutorial

Courses

Course nr.	Course name		
18-fi-2050-pr	Network and Cyber-physical Systems Lab		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Findeisen		Lab	3

Module name Laboratory Matlab/Simulink II					
Module nr. 18-fi-2100	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr.-Ing. Rolf Findeisen		

1	**Teaching content** The lab is split into the two parts Simulink and Control Engineering II. First the fundamentals of the simulation tool Simulink are introduced and their application to problems from different fields of application is trained. In the second part, the knowledge gained in the first part is applied to autonomously solve several control design problems as well as simulation tasks.
2	**Learning objectives** The students will be able to work with the tool MatLab/Simulink on their own and can solve tasks from the areas of control engineering and numericial simulation. The students will know the different design methods of the control system toolbox and the fundamental concepts of the simulation tool Simulink. They can practically apply the knowledge gathered in the lectures “System Dynamics and Control Systems I and II” and “Modelling and Simulation”.
3	**Recommended prerequisites for participation** The lab should be attended in parallel or after the lectures “System Dynamics and Control Systems II” and “Modelling and Simulation”
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - AUT, M.Sc. MedTec, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture notes for the lab tutorial can be obtained at the secretariat

Courses

Course nr.	**Course name**		
18-fi-2100-pr	Laboratory Matlab/Simulink II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Findeisen, M.Sc. Joachim Schaeffer, M.Sc. Philipp Holzmann		Lab	4

Module name					
Advanced Integrated Circuit Design Lab					
Module nr. 18-ho-2120	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1 Teaching content

Practical Design Tasks in Full Custom Design of Digital or Analog Ciruits using State-of-the-Art Commercial CAD Tools

2 Learning objectives

A student is, after successful completion of this module, able to

1. develop and verify transistor circuitry using Cadence
2. simulate logic and analog circuits (Pre- and Postlayout)
3. draw, verify and extract layout

After successful completion of this module the students are able to work constructively on a feasible solution. Aside, they are able to mutually support each other and present intermediate results to peers, and achieve an overall feasible solution.

3 Recommended prerequisites for participation

Lecture "Advanced Digital Integrated Circuit Design" or “Electronic and Integrated Circuits”

4 Form of examination

Module exam:
- Module exam (Study achievement, Oral/written examination, Default RS)

Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate). The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. MEC, M.Sc. etit - DT, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. iCE, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

ADIC Lecture Slide Copies
- John P. Uyemura: Fundamentals of MOS Digital Integrated Circuits
- Neil Weste et al.: Principles of CMOS VLSI Design

Courses

Course nr.	Course name		
18-ho-2120-pr	Advanced Integrated Circuit Design Lab		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Lab	**SWS** 3

Module name Simulation of Electrical Power Networks					
Module nr. 18-hs-2100	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1	**Teaching content** Modeling, simulating and planning electrical power networks with a wide range of nominal voltages under consideration of electrical equipment (overhead lines, cables, transformers, conventional power plants, renewable energy resources und reactive power compensation systems)
2	**Learning objectives** Upon completion of the module, students were taught: • Modeling various electrical power systems using the appropriate techniques. • Choice of static and dynamic simulation techniques after analysing the concrete simulation processes. • Understanding the behaviour of various equipment in the electric power system, especially renewable energy resources. • Interpretion of results based on the fundamental questions of modeling and simulating electrical power systems.
3	**Recommended prerequisites for participation** Basics of electrical power systems
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE
8	**Grade bonus compliant to §25 (2)**
9	**References** Script, Presentation Slides, Description of tutorial and basic network data

Courses

Course nr.	Course name	
18-hs-2100-pr	Simulation of Electrical Power Networks	
Instructor	**Type**	**SWS**
M.Sc. Anna Pfendler, M.Sc. Felix Korff, Prof. Dr.-Ing. Jutta Hanson, M.Sc. Manuel Schwenke	Lab	2

Module name					
Lighting Technology I					
Module nr. 18-kh-2010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Tran Quoc Khanh		

1 Teaching content

Structure and functionality of the human eye, terms and unit in lighting technology, photometry, radiometric and photometric properties of materials, filters, physiology of vision, colour theory, lighting, light sources.
Measurement of luminous flux, luminous intensity, illuminance, luminance, determination of the spectral responsivity function of the human eye, colorimetry colour rendering, colour as traffic signals, measuring of optical material characteristics, LED properties

2 Learning objectives

On completion of the module students will have learned the following:
- To list and connect terms, units and radiometric and photometric properties of materials in lighting technology
- to describe and understand structure and functionality of the human eye and the physiology of vision
- to illustrate basics of lighting, measuring methods and application.

They are able to measure base items in lighting technology, applying knowlegde of lighting and enhance them with experiments and have developed a better understanding for light and color.

3 Recommended prerequisites for participation

MSc ETiT, MSc Wi-ETiT, MSc MEC

4 Form of examination

Module exam:
- Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Technical examination, Oral examination, Weighting: 100 %)

7 Usability of the module

B.Sc. etit, M.Sc. MEC, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. MedTec, B.Sc. und M.Sc. iST, B.Sc. WI-etit

8 Grade bonus compliant to §25 (2)

9 References

Script for lecture: Lighting Technology I
Excersisebook: laboratory: lighting technology I

Courses

Course nr.	Course name		
18-kh-2010-vl	Lighting Technology I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Tran Quoc Khanh, Dr.-Ing. Babak Zandi, M.Sc. Felix Wirth		Lecture	2

	Course nr.	Course name		
	18-kh-2010-pr	Lighting Technology I		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Tran Quoc Khanh, Dr.-Ing. Babak Zandi, M.Sc. Felix Wirth		Lab	2

Module name Advanced Lighting Technology					
Module nr. 18-kh-2020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Tran Quoc Khanh		

1	**Teaching content** Chosen topics in lighting technology - current developments and applications: Street lighting, Physiology: Detektion / Glare / Lighing and Health, LED - Generation of white Light / State of the Art, Modern Methods of Light Measurement, Interiour Lighting, Display Technologies, Non-visual Light Impacts,UV-Applications, Automotive Lighting, Solar Modules.
2	**Learning objectives** On completion of the module students will have learned the following: They know current developments and applications, list and connect terms, to illustrate special topics of lighting, measuring methods and application. They are able to measure base items in lighting technology, applying knowlegde of lighting and dedicated applications and further to enhance them with experiments. They have developing a better understanding for light, color, perception and lighting situations.
3	**Recommended prerequisites for participation** Lighting Technology I
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. MedTec, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Excercisebook: laboratory: lighting technology II

Courses

Course nr.	**Course name**		
18-kh-2020-vl	Advanced Lighting Technology		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Tran Quoc Khanh		Lecture	2
Course nr.	**Course name**		
18-kh-2020-pr	Advanced Lighting Technology		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Tran Quoc Khanh		Lab	2

Module name Solid State Lighting					
Module nr. 18-kh-2060	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Tran Quoc Khanh		

1 Teaching content

Basics of light and colour perception; basics of solid state light sources; LEDs: material systems, structural shape, optics, phosphors; phosphor mixtures; colour and white LEDs; temperature, current and optical behaviour of LEDs; LED models; lifetime and defect mechanisms of LEDs; OLEDs and semiconductor lasers in lighting engineering; optical sensors; semiconductor based cameras; colour sensors; colour quality of solid state light sources; choice and combination of LEDs in practical LED luminaires; flicker; grouping (binning) of LEDs according to their technological parameters; lighting quality metrics; intelligent indoor lighting with LEDs: colour recognition, spectral reconstruction; intelligent automotive and outdoor lighting with LEDs; practical training: thermic, electric and lighting engineering related measurement of LED light sources.

2 Learning objectives

Principles and applications of the technology of solid state light sources in lighting engineering; LED technology and the optimisation of visual perception under LED light in modern lighting engineering.

3 Recommended prerequisites for participation

Lichttechnik I, II

4 Form of examination

Module exam:
- Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Technical examination, Oral examination, Weighting: 100 %)

7 Usability of the module

M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE

8 Grade bonus compliant to §25 (2)

9 References

- LED-Lighting: Technology and Perception (Khanh, Bodrogi, Vinh, Winkler; Editors,Wiley-VCH,2015)
- Introduction to Solid State Lighting (Zukauskas et al., Wiley, 2002)
- Light Emitting Diodes (Schubert; Cambridge Univ. Press, 2003)

Courses

Course nr.	Course name		
18-kh-2060-vl	Solid State Lighting		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Tran Quoc Khanh, Dr.-Ing. Alexander Herzog		Lecture	2

	Course nr.	Course name		
	18-kh-2060-pr	Praktikum Halbleiterlichttechnik		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Tran Quoc Khanh, Dr.-Ing. Alexander Herzog		Lab	2

Module name Multimedia Communications Lab II					
Module nr. 18-sm-2070	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Ralf Steinmetz		

1	**Teaching content** The course deals with cutting-edge development topics in the area of multimedia communication systems. Besides 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 competencies 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 • Adaptive educational technologies • Natural language processing in education The concrete list of topics can be found each semester on the corresponding teaching website of KOM.
2	**Learning objectives** The ability to solve and evaluate problems in the area of design and development of future multimedia communication networks and applications shall be acquired. Acquired competences are: • Design of complex communication applications and protocols • Implementing and testing of software components for distributed systems • Application of object-oriented analysis and design techniques • Acquisition of project management techniques for small development teams • Writing of software documentation and project reports • Presentation of project advances and outcomes
3	**Recommended prerequisites for participation** Keen interest to explore challenging topics which are cutting edge in technology and research. Further we expect: • Solid experience in programming Java and/or C# (C/C++) • Solid knowledge in object oriented analysis and design • Solid knowledge in computer communication networks are recommended • Lectures in Communication Networks I (II, III, or IV) are an additional plus
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination

6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, M.Sc. iCE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**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) • Joshua Bloch: "Effective Java Programming Language Guide" (ISBN-13: 978-0201310054) • 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-2070-pr	Multimedia Communications Lab II

Instructor	Type	SWS
Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing. Julian Zobel, M.Sc. Fridolin Siegmund, Prof. Dr.-Ing. Ralf Steinmetz	Lab	3

Module name					
Introduction to Scientific Computing with Python					
Module nr. 18-st-2070	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1 Teaching content

Scientific computing is introduced via six case studies. Exemplary engineering problems that are know from basic engineering courses are solved on a computer using fundamental methods from numerical mathematics. Opportunities and limitations of this approach are highlighted.

The required material on numerical mathematics is taught via preparatory scripts for each case study. During the practical exercises the methods are implemented in the current computing environment Python under the guidance of suitable teaching personnel.

The case studies cover the following numerical topics:

- Formulation and solution of systems of linear equations, sparse methods
- Integration of ordinary differential equations (ODE) and their analysis based on eigenvalues
- Mathematical optimization and automated differentiation
- Linear regression and approximation, first Machine Learning algorithms
- Discretization of simple partial differential equations (PDE)

2 Learning objectives

After completing the module, the students have learned to work on engineering problems with modern computer tools and to use important basic technologies of scientific computing in a targeted manner. In doing so, the students have been taught an algorithmic way of thinking and are able to assess the possibilities and limitations of computer-based computational methods.

3 Recommended prerequisites for participation

Etit 1 & 2, Mathe for etit 1-3

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

The exact form of the examination will be announced at the beginning of the first course. Either a report of experimental descriptions and/or a presentation of experimental results will be prepared.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B.Sc. etit, M.Sc. MEC, M.Sc. ESE, M.Sc. CE, M.Sc. etit - KTS, M.Sc. MedTec, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

Courses

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-st-2070-pr</td><td colspan="3">Course name
Introduction to Scientific Computing with Python</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. rer. nat. Florian Steinke, Prof. Dr.-Ing. Herbert De Gersem, Prof. Dr. rer. nat. Sebastian Schöps, Prof. Dr. techn. Heinz Köppl, Prof. Dr. rer. nat. Markus Meinert</td><td>Type
Lab</td><td>SWS
2</td></tr>
</table>

Module name Digital Signal Processing Lab					
Module nr. 18-zo-2030	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language English			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir		

1	**Teaching content** 1. Introduction to MATLAB 2. Discrete-Time Signals and Systems 3. Frequency-Domain Analysis using the DFT 4. Digital FIR Filter Design 5. IIR Filter Design using Analog Prototypes 6. Nonparametric Spectrum Estimation 7. Parametric Spectrum Estimation.
2	**Learning objectives** The students are able to apply skills acquired in the course Digital Signal Processing. These include the design of digital FIR and IIR filters as well as non-parametric and parametric spectrum estimation. Students learn how MATLAB is used to apply theoretical concepts and to demonstrate signal processing techniques by using hands-on application examples.
3	**Recommended prerequisites for participation** Fundamentals of Signal Processing
4	**Form of examination** Module exam: • Module exam (Study achievement, Written examination, Duration: 120 Min., Default RS) Exam (Duration: 120 min) and a Report (Lab Reports), Details will be announced at the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. MedTec, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**References** Lab manual

Courses

Course nr.	Course name		
18-zo-2030-pr	Digital Signal Processing Lab		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Abdelhak Zoubir		Lab	3

<table>
<tr><td colspan="7">Module name
Thin films and spintronics lab</td></tr>
<tr><td>Module nr.
18-me-2050</td><td colspan="2">Credit points
5 CP</td><td>Workload
150 h</td><td>Self-study
105 h</td><td>Module duration
1 Term</td><td>Module cycle
Every Semester</td></tr>
<tr><td colspan="4">Language
English</td><td colspan="3">Module owner
Prof. Dr. rer. nat. Markus Meinert</td></tr>
</table>

1	**Teaching content** In several blocks, students have the opportunity to produce magnetic thin films and devices in the lab and cleanroom and to measure their properties: • Production of metallic thin films using magnetron sputtering, giant magnetoresistance (GMR), and interlayer coupling (RKKY) • Production of an AMR-based "barber pole" magnetic field sensor using lift-off lithography • Measurement of magnetic hysteresis in thin films, characterization of magnetization and magnetic damping with GHz broadband spectroscopy, characteristics of magnetic tunnel junctions
2	**Learning objectives** Through the module, students learn how to handle equipment for the production of thin metallic layer systems. They carry out lithographic preparation in the cleanroom under the guidance of the instructor. Upon completion of the module, students will have a basic understanding of thin film technology, the associated process technology, and highly sensitive magnetic field sensors.
3	**Recommended prerequisites for participation** Introduction to spintronics
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Duration: 25 Min., Default RS) Report (including submission of programming code) and/or Presentation and/or Oral examination (25 minutes) and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. iCE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Script and slides for the internship Thin films and spintronics lab

Courses

Course nr.	Course name		
18-me-2050-pr	Thin films and spintronics lab		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Markus Meinert		Lab	3

2.3 Seminars

Module name Design of Electrical Machines and Actuators with Numerical Field Calculation					
Module nr. 18-bt-2110	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** Prof. Dr.-Ing. Yves Burkhardt		

1	**Teaching content** Introduction to Finite Element Method (FEM), Basic examples of electromagnetic devices designed in 2D with FEM, 2D electromagnetic Design of transformers, AC machines, permanent magnet devices; eddy current applications such as squirrel-cage machines (Example: Wind generator); Cooling systems and thermal design: Calculation of temperature distribution within power devices
2	**Learning objectives** Upon completion of the module, students will have a good knowledge in applying Finite Element software packages to basic field problems.
3	**Recommended prerequisites for participation** Strongly recommended is the attendance of lecture and active co-operation in the tutorial "Energy Converters - CAD and System Dynamics"
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE, B.Sc. und M.Sc. iST, M.Sc. etit - CMEE
8	**Grade bonus compliant to §25 (2)**
9	**References** Detailed textbook; Müller, C. Groth: FEM für Praktiker - Band 1: Grundlagen, expert-Verlag, 5. Aufl., 2000

Courses

Course nr.	**Course name**		
18-bt-2110-se	Design of Electrical Machines and Actuators with Numerical Field Calculation		
Instructor		**Type**	**SWS**
Dr.-Ing. Bogdan Funieru		Seminar	2

Module name					
Planning and Application of Electrical Drives (Drives for Electric Vehicles)					
Module nr. 18-bt-2120	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Yves Burkhardt		

1	**Teaching content** **Content of the lecture part:** Mono- and hybrid drive concepts, motor technology, DC and AC machines, drive systems, car dynamic, energy storage; **Content of the seminary work:** simulation of car with electric drive train, presentation of seminary work
2	**Learning objectives** After completing the module, students have acquired knowledge of the basic design procedures for electric drives in hybrid and electric cars.
3	**Recommended prerequisites for participation** Bachelor in Electrical Engineering or Mechatronics, "Electrical Drives and Machines" and "Power electronics"
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** • Textbook • Binder, A.: Electric machines and drives • Mitschke, M.: Dynamik der Kraftfahrzeuge, Springer Verlag Berlin

Courses

Course nr.	Course name		
18-bt-2120-se	Planning and application of electrical drives (Drives for electric vehicles)		
Instructor		**Type** Seminar	**SWS** 2

Module name					
KeySskills With a Focus on Language					
Module nr. 18-de-2118	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Katharina Dehn		

1 Teaching content

1. Seminar "Speaking and writing scientifically":

In the seminar, students are trained in competences that are expected of students in the Mechatronics degree programme in the area of oral and written communication. Own texts are worked out in scientific language so that they can be used in the subject studies.

The aim of the seminar is, on the one hand, to expand the students' general linguistic competence (above all vocabulary problems in the narrower sense) and, on the other hand, to make them transparent and aware of the culture-specific social expression typology (text type conventions, etc.) by making them aware of the intercultural change in the narrower sense (i.e. scientific habitus, speaker role, language style, etc.) in order to be able to comply with these, but also to avoid over-generalising inappropriate functionally imitative behaviour. The seminar is structured in a learner-centred way, as far as this is interculturally feasible. Authentic material is requested or produced.

Main topics:

- Punctuation (e.g. the hyphen in technical fields)
- Phonetics
- lexis/morphology (e.g. compound nouns)
- Semantics/grammar (e.g. passive and passive-verb tense)
- Text types and style levels
  Difference between oral and written expression
  Speech, CV, application, e-mails

2. Block seminar "Key Qualifications":

In the block seminar "Key Qualifications", students receive intercultural orientation training in five workshops, which on the one hand help them to find their way in everyday life in Germany and on the other hand give them support in making their stay here successful. The students are supported in structuring themselves and finding explanations as to why Germans are the way they are, which values are important in Germany and why different ideas can lead to misunderstandings. By working together, problems in living together are addressed and solution strategies are developed. Seminar blocks are

- Living and studying in Germany (1-day workshop)
- Working successfully in a team (1-day workshop)
- Effective learning and time management (1-day workshop)
- Expectations in the university context (1-day workshop)
- Phonetics (1-day workshop/consultation)

The intercultural trainer is in close contact with the coordinators of the Mechatronics Department in order to incorporate current topics into the workshops. If necessary, it is possible to involve staff and tutors of the department in the workshops at any time. Subject-related, organisational and, if necessary, social topics can be clarified effectively in this way.

2 Learning objectives

	After succesfully attending this module the students will be capable of • structuring their written and oral communication, • using techniques for lecturing and presenting, • designing handouts, • framing statements and reports scientifically, • understanding and analyzing Germany's cultural standards and habits, • coping with misunderstandings appearing in private and university contexts using strategies of de-escalation, • developing understanding for expectations within the university context and act accordingly, • defining strategies for successful teamwork and act accordingly, • employing methods of effective learning, • carrying out effective time management, • identifying their own potential and to cope with special challenges.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. CE
8	**Grade bonus compliant to §25 (2)**
9	**References**

To 1.:
Moll, Melanie / Winfried Thielmann (2017): Wissenschaftliches Deutsch. Studieren, aber richtig. Konstanz: UTB
Buchner, Patricia (2015): Campus Schreiben. München: Hueber Verlag.
Bayerlein, Oliver / Patricia Buchner (2013): Campus „Lesen“. München: Hueber Verlag.
Raindl, Marco Kay / Oliver Bayerlein (2015): Campus „Hören und Mitschreiben“. München: Hueber Verlag.
Bayerlein, Oliver (2014) Campus „Präsentieren und Diskutieren“. München: Hueber Verlag.
Richter, Ulrike / Nadja Fügert (2016): Wissenschaftlich arbeiten und Schreiben. Stuttgart: Klett Verlag
Richter, Ulrike / Nadja Fügert (2016): Wissenschaftssprache verstehen. Stuttgart: Klett Verlag
Richter, Ulrike / Nadja Fügert (2017): Mündliche Wissenschaftssprache. Stuttgart: Klett Verlag
Graefen, Gabriele / Melanie Moll (2011) Wissenschaftssprache Deutsch: lesen - verstehen - schreiben. Frankfurt: Peter Lang Verlag

To 2.:
Esselborn-Krumbiegel, H. (2007): Leichter lernen. Paderborn: Schöningh
Franck, N. (2004): Fit fürs Studium. München: Deutscher Taschenbuch Verlag
Hall, E./Hall, M. (1989): Understanding Cultural Differences: Germans, French and Americans. Yarmouth Minn.
Hofstede, G. (1991): Cultures and Organizations. New York: McGraw-Hill Education Ltd
Mehlhorn, G. (2005): Studienbegleitung für ausländische Studierende an deutschen Hochschulen. München: Iudicium
Stickel-Wolf, C./Wolf, J. (2006): Wissenschaftliches Arbeiten und Lerntechniken. Wiesbaden: Springer Gabler

Courses

Course nr. 18-de-2118-se	**Course name** Speaking and Writing in Academic Contexts			
Instructor		**Type** Seminar	**SWS** 2	
Course nr. 18-de-2119-se	**Course name** Seminar Key Skills			
Instructor		**Type** Seminar	**SWS** 2	

Module name Accelerator Physics and Technology					
Module nr. 18-dg-2070	**Credit points** 2 CP	**Workload** 60 h	**Self-study** 45 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Teaching content** Learn and understand the theoretical contexts in the field of accelerator physics; application of the theoretical background to practical examples related to current projects in the field.
2	**Learning objectives** The seminar addresses various topics relevant to accelerator physics and technology which in detail depend on the guest lecturers. So, insight into the current developments as well as into the different projects in the area is given. Moreover, the focus is put on the practical challenges arising during the design, construction and commissioning phase of the particular accelerator projects.
3	**Recommended prerequisites for participation** Basic knowledge in the field of accelerator physics and technology is useful, though not mandatory.
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. CE
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
18-dg-2070-se	Accelerator Physics and Technology		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Herbert De Gersem, Prof. Dr. rer. nat. Norbert Pietralla		Seminar	1

Module name Project Seminar Application, Simulation and Control of Power Electronic Systems					
Module nr. 18-gt-2030	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1	**Teaching content** In an introductory meeting topics according to power electronics and control of drives are given to the students. During the seminary problems can be treated concerning the following topics: • Simulation of power electronic systems plus analysis and evaluation of the models • Implementing and startup of power electronic systems, test stand development plus measurement of characteristic parameters • Modeling and simulation in the field of control of electrical drives • Implementing and startup of controlled drive systems • Suggested topics from the students are welcome
2	**Learning objectives** Upon completion of the module, students will have learned: • Autonomous familiarization with a given problem • Selection and evaluation of appropriate development tools • Familiarization with the used development tools • Practical experience in power electronics and control of drives • Logical presentation of the results in a report • Presentation skills
3	**Recommended prerequisites for participation** Lecture „Leistungselektronik 1“ or „Einführung Energietechnik“ and ggf. „Regelungstechnik I“ or similar
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Definition of project task
Courses	

	Course nr.	Course name		
	18-gt-2030-pj	Project Seminar Application, Simulation and Control of Power Electronic Systems		
	Instructor		**Type**	**SWS**
	M. Eng. Abdelmoumin Allioua, Prof. Dr.-Ing. Gerd Griepentrog		Project seminar	4

Module name Seminar Integrated Electronic Systems Design A					
Module nr. 18-ho-2160	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Teaching content** Research oriented Formulation of a Topic within the area of Microelectronics System Design; Creation of a written Documentation and Presentation; Team Work
2	**Learning objectives** A student is, after successful completion of this module, able to 1. gain a deep understanding of the chosen research subject in the field of integrated electronic systems, 2. write an essay on the chosen subject in a comprehesive form and present the outcome to an audience
3	**Recommended prerequisites for participation** Advanced Digital Integrated Circuit Design, CAD Methods, Computer Architectures, Programming Know-How
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral examination, Duration: 45 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. iCE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Topic-oriented Materials will be provided

Courses

Course nr.	**Course name**		
18-ho-2160-se	Seminar Integrated Electronic Systems Design A		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Seminar	2

Module name Seminar: Integrated Electronic Systems Design B					
Module nr. 18-ho-2161	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1 Teaching content

Research oriented Formulation of a Topic within the area of Microelectronics System Design; Creation of a written Documentation and Presentation; Team Work

2 Learning objectives

A student is, after successful completion of this module, able to

1. gain a deep understanding of the chosen research subject in the field of integrated electronic systems,
2. write an essay on the chosen subject in a comprehesive form and present the outcome to an audience

3 Recommended prerequisites for participation

Advanced Digital Integrated Circuit Design, CAD Methods, Computer Architectures, Programming Know-How

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral examination, Duration: 45 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral examination, Weighting: 100 %)

7 Usability of the module

M.Sc. etit - SAE, M.Sc. CE, M.Sc. iCE, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

Topic-oriented Materials will be provided

Courses

Course nr.	**Course name**		
18-ho-2161-se	Seminar: Integrated Electronic Systems Design B		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Seminar	3

<table>
<tr><td colspan="6">Module name
Computational Modeling for the IGEM Competition</td></tr>
<tr><td>Module nr.
18-kp-2100</td><td>Credit points
4 CP</td><td>Workload
120 h</td><td>Self-study
90 h</td><td>Module duration
1 Term</td><td>Module cycle
Every Semester</td></tr>
<tr><td colspan="3">Language
English</td><td colspan="3">Module owner
Prof. Dr. techn. Heinz Köppl</td></tr>
</table>

1	**Teaching 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** 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 prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. CE, M.Sc. MedTec, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**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					
International Summer School 'Microwaves and Lightwaves'					
Module nr. 18-pr-2020	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr. rer. nat. Sascha Preu		

1	**Teaching content** This summer school covers the fundamentals and the latest developments of microwave electronics, THz technology, and optical communication systems with particular focus on the physical concepts involved.
2	**Learning objectives** Students understand the presented research topics, e.g. • topics of microwave engineering, THz engineering, and optical communications • of related electronics • the influence of the relevant properties of materials and of waveguides on signal processing. They gain inside into the latest developments in these fields.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. iCE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** A script (English) will be distributed or slides can be downloaded.

Courses

Course nr.	Course name		
18-pr-2020-se	International Summer School "Microwaves and Lightwaves"		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sascha Preu		Seminar	2

<table>
<tr><td colspan="6">Module name
One World Signal Processing Seminar Series</td></tr>
<tr><td>Module nr.
18-pe-2090</td><td>Credit points
4 CP</td><td>Workload
120 h</td><td>Self-study
90 h</td><td>Module duration
1 Term</td><td>Module cycle
Every Semester</td></tr>
<tr><td colspan="3">Language
English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Marius Pesavento</td></tr>
</table>

1	**Teaching content** This seminar series covers addresses latest trends in Signal processing with focus on mobile communications, machine learning and optimization.
2	**Learning objectives** Students understand the presented research topics, e.g., the latest trends in • Signal processing • Communications • Graph signal processing • Machine learning for communications and data analysis • Coexistence of radar and communications • Compressed sensing and sampling theory • Convex Optimization Students learn to prepare themselves for the participation in a scientific seminar based on reference to the scientific literature. Students learn to participate in scientific seminars, to contribute with thoughtful comment and appropriate questions and to initiate a fruitful scientific discussion. Students learn to summarize the main scientific findings and statements of the talk in a short written report. Students learn to summarize the main scientific findings of the talk in a scientific discussion and to defend the main statements.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Slides can be downloaded. URL for One World Signal Processing Seminar Series: https://www1.se.cuhk.edu.hk/ htwai/oneworld
Courses	

	Course nr.	**Course name**		
	18-pe-2090-se	One World Signal Processing Seminar Series		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Marius Pesavento, M.Sc. Raphael Müller		Seminar	2

Module name Multimedia Communications Seminar II						
Module nr. 18-sm-2090	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Every Semester	
Language German/English			**Module owner** Prof. Dr.-Ing. Ralf Steinmetz			

1	**Teaching content** This seminar deals with current and upcoming trends relevant to the future development of multimedia communication systems. The educational objective of this seminar is to gain knowledge about future research trends in different areas. To this aim, an extensive literature research will be performed, as well as the writing-up of a report and the presentation of selected, high-quality research topics from current leading magazines, newspapers and conferences in the web technologies research area. Some potential topics are: • Knowledge & Educational Technologies • Self organizing Systems & Overlay Communication • Mobile Systems & Sensor Networking • Service-oriented Computing • Multimedia Technologies & Serious Games
2	**Learning objectives** Students shall acquire profound knowledge from current scientific publications, standards and literature on multimedia communication systems and applications which will build the future Internet. In so doing, the students will develop the following competencies: • Search for and review relevant scientific literature. • Analyse and evaluate complex technical and scientific information. • Write technical and scientific abstracts and summary reports. • Present technical and scientific information.
3	**Recommended prerequisites for participation** Solid knowledge in computer communication networks. Lectures in Communication Networks I and II are recommended.
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, M.Sc. iCE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Depending on specific topic (selected articles of journals, magazines, and conferences).
Courses	

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-sm-2090-se</td><td colspan="3">Course name
Multimedia Communications Seminar II</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing. Julian Zobel, M.Sc. Fridolin Siegmund, Prof. Dr.-Ing. Ralf Steinmetz</td><td>Type
Seminar</td><td>SWS
2</td></tr>
</table>

Module name					
Multimedia Communications Seminar I					
Module nr. 18-sm-2300	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Ralf Steinmetz		

1 Teaching content

The seminar investigates current and upcoming topics in multimedia communication systems, which are expected to be of utmost importance for the future evolution of the Internet and information technolgy in goal. The goal is to learn more about multimedia communication systems by studying, summarizing, and presenting top quality papers from recent high quality networking research journals, magazines, or conferences. The selection of topics corresponds to the research area of participating researchers.

Possible topics are:

- Knowledge & Educational Technologies
- Self organizing Systems & Overlay Communication
- Mobile Systems & Sensor Networking
- Service-oriented Computing
- Multimedia Technologies & Serious Games

2 Learning objectives

The students are actively studying cutting edge scientific articles, standards, and books about multimedia communication systems and applications, which are expected to be of utmost important for the future of the Internet.

Students acquire competences in the following areas:

- Searching and reviewing of relevant scientific literature
- Analysis and evaluation of complex technical and scientific information
- Writing of technical and scientific summaries and short papers
- Presentation of complex technical and scientific information

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. MEC, M.Sc. CE, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

Depending on specific topic (selected articles of journals, magazines, and conferences).

Courses

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-sm-2300-se</td><td colspan="3">Course name
Multimedia Communications Seminar I</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing. Julian Zobel, M.Sc. Fridolin Siegmund, Prof. Dr.-Ing. Ralf Steinmetz</td><td>Type
Seminar</td><td>SWS
2</td></tr>
</table>

Module name Seminar Software System Technology					
Module nr. 18-su-2080	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1	**Teaching content** In this course, the students produce scientific reports from changing subject areas. Each student has to explore a subject related to IT system development and produce a written report as well as a final talk with a presentation.
2	**Learning objectives** Upon successful completion of the module, the students will be able to assess the reliability of information sources and explore an unknown topic under scientific aspects. The students learn to support the exploration by a literature research and to analyze the subject critically. They achieve the skills to present a definite subject in a written report as well as in an oral presentation.
3	**Recommended prerequisites for participation** Basic knowledge in software engineering and programming languages
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, B.Sc. CE, M.Sc. iCE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/sst-s

Courses

Course nr.	**Course name**		
18-su-2080-se	Seminar Software System Technology		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Andreas Schürr, M.Sc. Alexej Andres		Seminar	2

Module name Advanced Topics in Statistical Signal Processing					
Module nr. 18-zo-2040	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir		

1	**Teaching content** The course covers the fundamentals of detection and estimation theory. These are extended by advanced topics in statistical signal processing. Applications are typically from the following areas: Detection in Radar Applications; Robust Estimation; Prediction, Filtering, and Tracking with the Kalman Filter; Sensor Array Signal Processing, Direction of Arrival Estimation, and Source Detection; Time-Frequency Analysis. Topics may change from semester to semester. The course includes a series of lectures followed by a supervised research seminar over approximately 2 months. The main topics covered are: • Estimation theory • Detection theory • Robust estimation theory • Seminar projects: e.g., microphone arrays/beamforming, localization and tracking, radar/ultrasonic imaging, acoustic source localization, estimation of number of sources
2	**Learning objectives** After completing the module, students will be able to work independently on advanced topics in signal processing and reproduce existing results. The students can present these results and discuss them scientifically.
3	**Recommended prerequisites for participation** DSP, general interest in signal processing
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. MedTec, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**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-2040-se	Advanced Topics in Statistical Signal Processing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Abdelhak Zoubir, M.Sc. Pertami Kunz		Seminar	4

Module name					
Signal Detection and Parameter Estimation					
Module nr. 18-zo-2050	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir		

1 Teaching 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 of Detection and Estimation Theory
- Hypothesis Testing:
  - Bayesian/Ideal Observer/Neyman-Pearson Tests
  - Receiver Operating Characteristics
  - Uniformly Most Powerful Tests
  - 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

After successful completion of the module, students know the basics of detection and estimation theory. They can design hypothesis tests and estimators for existing problems and implement them in Matlab on their own. In addition, students will be able to review existing work on detection and estimation independently. They can adequately present the methods and results from existing publications and discuss them scientifically.

3 Recommended prerequisites for participation

DSP, general interest in signal processing

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. MedTec, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS

8 Grade bonus compliant to §25 (2)

9	**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

Module name Data Science II					
Module nr. 18-zo-2120	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir		

1 Teaching content

The course covers the following topics:

- Data Science Advanced Methods
- Data Management + Big data frameworks
- Statistical Learning
  - Recommender Systems
  - Deep Learning
  - Unsupervised Learning
  - Text data analysis
- Final application project. Flexibility to choose from list of projects or come up with own project. Examples:
  - Sound classification
  - Heart rate analysis
  - Activity recognition with acceleration data
  - Hyperspectral data
  - Image classification
  - Health survey

2 Learning objectives

After successful completion of the module, the students have an in-depth understanding of data science with a strong practical relevance. They have become familiar with modern data science technologies (from big data to novel methods in machine learning) and can apply them in a project with real world data.

3 Recommended prerequisites for participation

Data Science I (Lecture)

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Duration: 90 Min., Default RS)

Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS

8 Grade bonus compliant to §25 (2)

9 References

Lecture notes and slides can be downloaded here:

- http://www.spg.tu-darmstadt.de
- Moodle platform

Further reading:

- Wes McKinney: Python for Data Analysis, O'Reilly, 2017
- Christopher M. Bishop: Pattern Recognition and Machine Learning, 2011
- James, Witten, Hastie and Tibshirani, Introduction to Statistical Learning, Springer, 2017

Courses

Course nr.	**Course name**		
18-zo-2120-se	Data Science II		
Instructor		**Type**	**SWS**
Dr.-Ing. Christian Debes		Seminar	4

2.4 Project Seminars

Module name Project Seminar Robotics and Computational Intelligence					
Module nr. 18-ad-2070	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1	**Teaching content** The following topics are taught in the lecture: **Industrial robots** 1. Types and applications 2. Geometry and kinematics 3. Dynamic model 4. Control of industrial robots **Mobile robots** 1. Types and applications 2. Sensors 3. Environmental maps and map building 4. Trajectory planning Group projects are arranged in parallel to the lectures in order to apply the taught material in practical exercises.
2	**Learning objectives** Upon successful completion of the module, students are 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 9. presenting the results of the project.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7	**Usability of the module** M.Sc. MEC, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - AUT, M.Sc. MedTec, B.Sc. und M.Sc. iST			
8	**Grade bonus compliant to §25 (2)**			
9	**References** Adamy: Lecture notes (available for purchase at the FG office)			
Courses				
	Course nr. 18-ad-2070-pj	**Course name** Project Seminar Robotics and Computational Intelligence		
	Instructor Prof. Dr.-Ing. Jürgen Adamy		**Type** Project seminar	**SWS** 4

<table>
<tr><td colspan="7">Module name
Project Seminar Automatic Control Systems</td></tr>
<tr><td>Module nr.
18-ad-2080</td><td colspan="2">Credit points
8 CP</td><td>Workload
240 h</td><td>Self-study
180 h</td><td>Module duration
1 Term</td><td>Module cycle
Winter term</td></tr>
<tr><td colspan="4">Language
German</td><td colspan="3">Module owner
Prof. Dr.-Ing. Jürgen Adamy</td></tr>
<tr><td>1</td><td colspan="6">Teaching content
In a small project group under the guidance of a scientific assistant, individual projects from a subject area of automation technology are worked on.</td></tr>
<tr><td>2</td><td colspan="6">Learning objectives
After attending the module, a student is capable of:

1. planing a small project,
2. organizing the work within a project team,
3. searching for scientific background information on a given project,
4. creating ideas on how to solve problems arising in the project,
5. presenting the results in a scientific report, and
6. giving a talk on the results of the project.</td></tr>
<tr><td>3</td><td colspan="6">Recommended prerequisites for participation</td></tr>
<tr><td>4</td><td colspan="6">Form of examination
Module exam:
• Module exam (Study achievement, Oral/written examination, Default RS)
Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.</td></tr>
<tr><td>5</td><td colspan="6">Prerequisite for the award of credit points
Passing the final module examination</td></tr>
<tr><td>6</td><td colspan="6">Grading
Module exam:
• Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td colspan="6">Usability of the module
M.Sc. MEC, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - AUT, B.Sc. und M.Sc. iST</td></tr>
<tr><td>8</td><td colspan="6">Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td colspan="6">References
Training course material</td></tr>
<tr><td colspan="7">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-ad-2080-pj</td><td colspan="5">Course name
Project Seminar Automatic Control Systems</td></tr>
<tr><td colspan="4">Instructor
Prof. Dr.-Ing. Jürgen Adamy, M.Sc. Linus Groß</td><td>Type
Project seminar</td><td>SWS
4</td></tr>
</table>

Module name Energy Converters and Electric Drives					
Module nr. 18-bt-2130	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Yves Burkhardt		

1	**Teaching content** From the topics of proposed scientific theses, subtasks are derived. Groups of two to four students will work on these subtasks under supervision of a tutor. The focus of the work can be either theoretical or experimental and contains scientific problems in the field of electric energy conversion and electric drives. For study program Mechatronics this corresponds to the Advanced Design Project. Independent from the individual topics, the topic "Design and testing of a small 3-phase induction machine" can always be chosen.
2	**Learning objectives** Upon completion of the module, students will have acquired knowledge of: Energy Converters, Electric Drives, Control of Electric Drives, Teamwork, Writing Scientific Reports, Presentation
3	**Recommended prerequisites for participation** Fundamentals on Electrical Engineering, Three-phase Systems, Mechanics; Lecture „Electrical Machines and Drives“
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE
8	**Grade bonus compliant to §25 (2)**
9	**References** Depending on the project task; manuscripts from the lectures „Electrical Machines and Drives“, „Motor development for electric Drive Systems“, „Regelungstechnik 1“

Courses

Course nr.	**Course name**		
18-bt-2130-pj	Energy Converters and Electric Drives		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Yves Burkhardt		Project seminar	3

Module name Science in Practice I					
Module nr. 18-dg-2130	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Teaching content** Acquiring basic scientific skills based on concrete examples from the literature.
2	**Learning objectives** The students possess basic scientific skills. They are able to discover important literature for a given topic and to judge critically the corresponding content. They are familiar with numerical techniques, especially convergence studies relevant for praxis. The students are capable of analyzing errors within simulations and of judging accuracy requirements, e.g., with respect to errors in input data.
3	**Recommended prerequisites for participation** Good understanding of electromagnetic fields, knowledge about numerical simulation methods.
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral examination, Duration: 20 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. CE
8	**Grade bonus compliant to §25 (2)**
9	**References** Material related to the topic is provided.

Courses

Course nr.	**Course name**		
18-dg-2130-pj	Science in Practice I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Herbert De Gersem		Project seminar	4

Module name Science in Practice II					
Module nr. 18-dg-2140	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Teaching content** Working on different scientific topics based on techniques acquired in Science in Practice I.
2	**Learning objectives** The students are capable of succesfully working on new scientific topics from the numerical field simulation in a reasonable time. They are able to understand new methods, to implement them if necessary and to carry out simulations. Thereby methodologies discussed in Science in Practice I, especially concerning the solution of systems of equations, as well as convergence and error analysis are employed.
3	**Recommended prerequisites for participation** Good understanding of electromagnetic fields, knowledge about numerical simulation methods.
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral examination, Duration: 20 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. CE
8	**Grade bonus compliant to §25 (2)**
9	**References** Material related to the topic is provided.

Courses

Course nr. 18-dg-2140-pj	**Course name** Science in Practice II		
Instructor Prof. Dr.-Ing. Herbert De Gersem		**Type** Project seminar	**SWS** 4

<table>
<tr><td colspan="8">Module name
Serious Games Project Seminar</td></tr>
<tr><td colspan="2">Module nr.
18-de-2070</td><td>Credit points
9 CP</td><td>Workload
270 h</td><td>Self-study
195 h</td><td colspan="2">Module duration
1 Term</td><td>Module cycle
Every Semester</td></tr>
<tr><td colspan="4">Language
German/English</td><td colspan="4">Module owner
PD Dr.-Ing. Stefan Göbel</td></tr>
<tr><td>1</td><td colspan="7">Teaching content
In this project the students will design concepts and implement prototypes in the field of serious games (e.g. in education, health and sports).

The topics relate to current research questions in the field, partly in cooperation with partners from the games industry and/or Serious Games users.</td></tr>
<tr><td>2</td><td colspan="7">Learning objectives
After successfully attending the course, the students can conceptualize and prototypically implement practical tasks in the context of “Serious Games”. Additionally they acquire practical knowledge in the area of project management, which they can apply to their own topic as well as transfer it to future projects. Besides, the students are able to present their findings in front of an audience applying a number of different presentation techniques and to actively participate in a scientific discussion on their topic.</td></tr>
<tr><td>3</td><td colspan="7">Recommended prerequisites for participation
Programming skills (the language will depended on the topic and may be chosen at will for certain topics).</td></tr>
<tr><td>4</td><td colspan="7">Form of examination
Module exam:
Module exam (Study achievement, Oral/written examination, Default RS)
Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.</td></tr>
<tr><td>5</td><td colspan="7">Prerequisite for the award of credit points
Pass exam (100%)</td></tr>
<tr><td>6</td><td colspan="7">Grading
Module exam:
Module exam (Study achievement, Oral/written examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td colspan="7">Usability of the module
M.Sc. CE, B.Sc. CE, B.Sc. und M.Sc. iST</td></tr>
<tr><td>8</td><td colspan="7">Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td colspan="7">References</td></tr>
<tr><td colspan="8">Courses</td></tr>
<tr><td rowspan="2"></td><td colspan="2">Course nr.
18-de-2070-pj</td><td colspan="5">Course name
Serious Games Project Seminar</td></tr>
<tr><td colspan="5">Instructor
PD Dr.-Ing. Stefan Göbel</td><td>Type
Project seminar</td><td>SWS
5</td></tr>
</table>

Module name Project Course Practical Application of Mechatronics					
Module nr. 18-fi-2110	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr.-Ing. Rolf Findeisen		

1	**Teaching content** Teams of 2-4 students work on different mechatronic projects under the guidance of a project coordinator from the institute.The projects mainly cover the following subject areas: • Modeling, analysis, and design of mechatronic systems • Robust control design • System analysis, supervision and fault diagnosis • Modeling and identification Application areas are mechatronic actuators, machine tools, production lines, test benches, automobiles, quadrocopters.
2	**Learning objectives** After completing the project, the students will be familiar with the individual steps of investigating a mechatronic project. This includes in particular the compilation of a system specification as well as critical discussions and systematic selection of appropriate mechatronic solutions and their real technical implementation. Doing so, the students learn the practical application of mechatronic methods taught in the lectures to real world problems. Additionally, in this project course, the students are supposed to improve their professional skills. These skills include e.g. teamwork, presentation techniques and systematic information retrieval.
3	**Recommended prerequisites for participation** Lectures „System Dynamics and Automatic Control Systems I“, „System Dynamics and Automatic Control Systems II“
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - AUT, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Handouts will be distributed at start of the project (e.g. hints for writing project documentation, etc.)

Courses

Course nr.	**Course name**	
18-fi-2110-pj	Project Course Practical Application of Mechatronics	
Instructor	**Type**	**SWS**
Dr.-Ing. Anton Savchenko, Prof. Dr.-Ing. Rolf Findeisen	Project seminar	4

Module name Project Course Control Engineering					
Module nr. 18-fi-2120	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Rolf Findeisen		

1	**Teaching content** Teams of 2 - 4 students work on different control engineering projects under the guidance of a project coordinator from the institute. The projects mainly cover the following subject areas: • Modelling, analysis and design of multivariable control systems • Modelling, analysis and design of distributed parameter systems • Robust control design • System analysis, supervision and fault diagnosis • Modelling and identification Application areas are machine tools, production lines, test benches, process control, automobiles.
2	**Learning objectives** After completing of this module the students will be familiar with the individual steps of investigating a control engineering project. This includes in particular the compilation of a system specification as well as critical discussions and systematic selection of appropriate control engineering solutions and their real technical implementation. Doing so the students learn the practical application of control engineering methods taught in the module “System Dynamics and Control Systems I” to real world problems. Additionally, in this module the students are supposed to improve their professional skills. These skills include e.g. teamwork, presentation techniques and systematic information retrieval.
3	**Recommended prerequisites for participation** Lecture “System Dynamics and Control Systems I”
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - AUT, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Handouts will be distributed at start of the project (e.g. Hints for writing a project documentation, etc.)

Courses

Course nr.	**Course name**		
18-fi-2120-pj	Project Course Control Engineering		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Findeisen		Project seminar	4

Module name					
Project Seminar Biomedical Optics					
Module nr. 18-fr-1020	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr. habil. Torsten Frosch		

1	**Teaching content** This module is based on practical work on current, promising and trend-setting topics in biophotonics. We focus on applications of optical spectroscopy and microscopy in medical technology. Students will gain a deeper insight into practical work with lasers, optics, spectrometers, microscopes, etc. Participation in current research projects are possible, depending on the number of participants. The experimental results are evaluated using advanced techniques and methods of data processing and statistics and are documented in reports following scientific standards.
2	**Learning objectives** After successful completion of this module, students will be able to analyze and evaluate biophotonic methods and techniques. In addition, they have learned to plan and implement their own projects independently and collaborate in teams. They are able to apply experimental skills and advanced techniques and methods of data analysis. Depending on the task, students learn to independently analyze, improve, or build up optical setups from scratch. In addition, it is possible to program software for controlling devices and to analyze medically relevant samples. Furthermore, the measurement results are evaluated, presented, and interpreted in a scientific context. With the gained knowledge, students are able to critically analyze existing setups or instruments and develop their own approaches. In addition, students gain experience in preparing written reports according to scientific standards. They also practice presenting their work results to a professional or lay audience. Competencies such as the communication of specialist expertise to the public, the social relevance of the topics, teamwork, and the critical judgment of the reliability of information sources are taught.
3	**Recommended prerequisites for participation** Module Principles of Optics for Biomedical Engineering
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References**

Current scientific literature is recommended separately for the individual experiments. The following books can serve as a general reference:

- Bahaa E. A. Saleh und Malvin Carl Teich, Optik und Photonik, Wiley
- Eugen Hecht, Optik, Oldenburg Verlag
- Frank L. Pedrotti, Leno S. Pedrotti, Werner Bausch, Hartmut Schmidt, Optik für Ingenieure, Springer
- Herman Haken, Hans Christoph Wolf, Atom- und Quantenphysik, Springer
- Herman Haken, Hans Christoph Wolf, Molekülphysik und Quantenchemie, Springer
- Peter W. Atkins, Julio de Paula, Michael Bär, Physikalische Chemie, Wiley
- Wolfgang Demtröder, Laserspektroskopie 1&2, Springer

Courses

Course nr.	**Course name**		
18-fr-1020-pj	Project Seminar Biomedical Optics		
Instructor		**Type**	**SWS**
Dr. rer. nat. Andreas Merian, Prof. Dr. habil. Torsten Frosch, M.Sc. Phil Reize		Project seminar	4

Module name Artificial Intelligence in Medicine Challenge					
Module nr. 18-ha-2010	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr.-Ing. Christoph Hoog Antink		

1	**Teaching 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** Students can independently apply current AI / machine learning methods to solve medical problems. They have successfully independently developed, optimized and tested code that has withstood external evaluation. Graduates are enabled to apply methodological competencies, such as teamwork, in everyday professional life.
3	**Recommended prerequisites for participation** • Basic programming skills in Python • 18-zo-1030 Fundamentals of Signal Processing
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. CE, B.Sc. MedTec, M.Sc. MedTec, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**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.	**Course name**		
18-ha-2010-pj	Artificial Intelligence in Medicine Challenge		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christoph Hoog Antink		Project seminar	4

Module name Project Seminar Reconfigurable Systems					
Module nr. 18-hb-2040	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr.-Ing. Christian Hochberger		

1 Teaching content

Students will work on their own or in two-person teams in this course. Topics and application context will be defined individually for each group. In this course reconfigurable architectures will be investigated. This particularly means the extension, improvement, or adaptation of components and tools for reconfigurable architectures as well as the prototypical implementation of applications on such reconfigurable architectures. Usually, the course starts with a literature search to get acquainted with the underlying architecture. This is followed by the practical part and finally the results are presented in a written report and a presentation.

2 Learning objectives

Successful students will know how to use reconfigurable systems within a given application context. They can use tools to program these systems and know how to map an application onto a given reconfigurable architecture. They are capable to evaluate the performance critical parts of an application. They understand the implications of different coding styles for a particular task.

3 Recommended prerequisites for participation

- Knowledge of reconfigurable devices (cf. course computer systems II)
- Knowledge of computer architecture (cf. course computer systems I)
- Solid programming skills (either in C or Java depending on the application scenario).

4 Form of examination

Module exam:
- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, M.Sc. iCE, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

Will be given to the students during the individual seminar kick-off meeting.

Courses

Course nr.	**Course name**		
18-hb-2040-pj	Project Seminar Reconfigurable Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Project seminar	3

Module name Project Seminar Systems of Biomedical Engineering					
Module nr. 18-ha-2030	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Christoph Hoog Antink		

1	**Teaching content** Within this module, students work independently in small project teams on individual tasks from the field of systems of biomedical engineering. The focus is on the development of systems consisting of hardware and software, e.g. for automated diagnosis or therapy.
2	**Learning objectives** After completing the module, students will be able to independently abstract the technical requirements for a system in the area of biomedical engineering (e.g. for measuring and evaluating or simulating a physiological process). They can independently derive sub-projects from these requirements and create time schedules. They have successfully developed, optimized and tested a system comprising e.g. hardware and software. Graduates are enabled to apply methodological competencies, such as teamwork, in their everyday professional life.
3	**Recommended prerequisites for participation** Interest in working independently on hardware and software
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. CE, M.Sc. MedTec, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Leonhardt, S., & Walter, M. (Eds.). (2016). Medizintechnische Systeme: Physiologische Grundlagen, Gerätetechnik und automatisierte Therapieführung. Springer-Verlag.

Courses

Course nr.	**Course name**		
18-ha-2030-pj	Project Seminar Systems of Biomedical Engineering		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christoph Hoog Antink		Project seminar	4

Module name Project Seminar Network calculation					
Module nr. 18-hs-2110	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr.-Ing. Jutta Hanson		

1	**Teaching content** As an introduction, the principles of modeling electrical networks will be presented. Subsequently, a simulation program applicable for network calculation is presented and applied by the participants in computer exercises. The participants then work independently on a given problem from the field of modeling and simulation in the electrical power supply system.
2	**Learning objectives** Upon successful completion of the module, students were taught: • Knowledge of a simulation program used for network calculation • Elaboration of a given technical problem from the field of network planning or calculation • Independent elaboration of the necessary investigations and conception of corresponding simulations • Logical and concise presentation of the results in a report in the format of a scientific paper
3	**Recommended prerequisites for participation** Lectures „ Power Systems" I und II
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE
8	**Grade bonus compliant to §25 (2)**
9	**References** Script, program description, exercise task, project task topic.

Courses

Course nr.	**Course name**		
18-hs-2110-pj	Project Seminar Network calculation		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jutta Hanson		Project seminar	3

Module name Project Seminar Advanced µWave Components & Antennas					
Module nr. 18-jk-2060	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1 Teaching content

Groups of 2-3 students per project. Students work out a well defined fundamental or actual research- related problem. The projects will be actualized in each cycle being offered and introduced at the beginning. Each group will be supervised individually. The projects comprises modern antennas for multitudinous applications, electronically-steerable antennas, RFIDs, RF sensors, adaptive tunable components such as matching networks, filter, passive mixer and modulator for next-generation mobile terminals and sensor systems.

2 Learning objectives

Research-oriented Project Seminar in groups of 2-3 students per project with individual supervision. Students will learn

- how to solve scientific hardware-oriented problems
- working out concepts
- how to design, realize and characterize RF devices
- how to use commercial software and characterization tools
- to evaluate and discuss their work in the context of the state-of-art in this field
- to write a brief scientific report about their work
- to present and discus their results at the end of the Project Seminar

3 Recommended prerequisites for participation

Fundamentals of Microwave Engineering I and Antennas and Adaptive Beamforming

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral examination, Duration: 30 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral examination, Weighting: 100 %)

7 Usability of the module

M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. iCE

8 Grade bonus compliant to §25 (2)

9 References

Publications will be hand out to them. Software and characterization tools as well as tools to realize RF devices are available.

Courses

Course nr.	**Course name**		
18-jk-2060-pj	Project Seminar Advanced µWave Components & Antennas		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Jakoby, Dr.-Ing. Martin Schüßler		Project seminar	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	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1	**Teaching 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** 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 prerequisites for participation** Biomedical Microwave Engineering
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral examination, Duration: 30 Min., Default RS) The type of examination will be announced in the first lecture. Possible types include presentation (10 minutes) and an oral examination (30 minutes).
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**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					
Advanced Project Seminar Particle Accelerator Technology					
Module nr. 18-kb-2030	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Harald Klingbeil		

1	**Teaching content** Work on a complex, research-oriented 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** Students will be able to solve complex research-oriented 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 prerequisites for participation** Good understanding of electromagnetic fields, broad knowledge of different electrical engineering disciplines.
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. CE, M.Sc. etit - CMEE
8	**Grade bonus compliant to §25 (2)**
9	**References** Suitable material is provided based on specific problem.

Courses

Course nr.	Course name		
18-kb-2030-pj	Advanced Project Seminar Particle Accelerator Technology		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Harald Klingbeil, M.Sc. Sebastian Orth, M.Sc. Yi Jin, M.Sc. Christoph Wegmann		Project seminar	4

<table>
<tr><td colspan="6">Module name
Project Seminar Application in High-Voltage Technology</td></tr>
<tr><td>Module nr.
18-kc-2040</td><td>Credit points
6 CP</td><td>Workload
180 h</td><td>Self-study
135 h</td><td>Module duration
1 Term</td><td>Module cycle
Every Semester</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr. Myriam Koch</td></tr>
</table>

1	**Teaching content** Realization of a Project from the Design to the Implementation of High Voltage Setups
2	**Learning objectives** The students can apply the methodology of design and development from the very first customer requirements specification up to design and type tests and documentation of equipment in high-voltage technology. They have successfully experienced team work and self-independently developed, built and tested a real device from the beginning.
3	**Recommended prerequisites for participation** High-voltage technology I and II, Power Laboratory I or II
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE
8	**Grade bonus compliant to §25 (2)**
9	**References** depending on actual project

Courses

<table>
<tr><td>Course nr.
18-kc-2040-pj</td><td colspan="2">Course name
Project Seminar Application in High-Voltage Technology</td></tr>
<tr><td>Instructor
M.Sc. Michael Kempf, Prof. Dr. Myriam Koch</td><td>Type
Project seminar</td><td>SWS
3</td></tr>
</table>

Module name Project seminar Applications of Lighting Engineering					
Module nr. 18-kh-2051	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Tran Quoc Khanh		

1	**Teaching content** The project seminar deals with the following subjects: automotive lighting, interior lighting, exterior lighting; generation, perception and cognition of the visual stimulus (luminaires, displays, projection); LED/OLED technology; physical and psychophysical light measurement; illuminating engineering, color perception.
2	**Learning objectives** Upon completion of the module, students will be able to apply interdisciplinary thinking in lighting engineering independently in project teams or on their own.
3	**Recommended prerequisites for participation** Lighting Technology I-II
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture notes of Lighting Technology I (Khanh); Lecture slides of our Laboratory; Book “LED Lighting: Technology and Perception” (Khanh et al., Wiley); Book „Farbwiedergabe“ (Khanh et al., Pflaum-Verlag); specific literature depending on the topic, publications.

Courses

Course nr.	**Course name**		
18-kh-2051-pj	Project seminar Applications of Lighting Engineering		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Tran Quoc Khanh		Project seminar	3

Module name Project seminar Advanced Applications of Lighting Engineering					
Module nr. 18-kh-2052	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr.-Ing. Tran Quoc Khanh		

1	**Teaching content** For the project seminar, a question from the following topics can be addressed: Automotive lighting technology, light for the automated car, interior and exterior lighting; Smart Lighting; Human Centric Lighting (HCL); plant lighting; generation, perception and cognition of the visual stimulus (luminaires, displays, projection); LED/OLED technology; physical and psychophysical light measurement technology; lighting technology, color perception, virtual reality tests for light simulations. The aim of this project seminar is the practical implementation of the material acquired in the course of study in the form of a project work. The fundamentals of the module and the project seminar "Lighting Applications" are applied and deepened.
2	**Learning objectives** Upon completion of the module, students will be able to plan, implement and validate lighting technology issues. In addition, they will have learned how to abstract questions, communicate information in a project-dependent manner, and present their results.
3	**Recommended prerequisites for participation** Lighting Technology I-II, Project seminar Applications of Lighting Engineering
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture notes of Lighting Technology I (Khanh); Lecture slides of our Laboratory; Book "LED Lighting: Technology and Perception" (Khanh et al., Wiley); Book „Farbwiedergabe" (Khanh et al., Pflaum-Verlag); specific literature depending on the topic, publications.

Courses

Course nr.	Course name		
18-kh-2052-pj	Project seminar Advanced Applications of Lighting Engineering		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Tran Quoc Khanh		Project seminar	3

Module name					
Project seminar Special Applications of Lighting Engineering					
Module nr. 18-kh-2053	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 195 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Tran Quoc Khanh		

1 Teaching content

For the project seminar a question from the following subject areas can be worked on: Automotive lighting, light for autonomous cars, interior lighting, exterior lighting; smart lighting; human centric lighting (HCL); horticulture lighting; generation, perception and cognition of visual stimuli (luminaires, displays, projection); LED/OLED technology; physical and psychophysical light measurement; illuminating engineering, color perception, virtual reality tests for light-simulation. The objective of this project seminar is the practical implementation of the knowledge acquired during the study in the form of research or project work in an interdisciplinary context, which also takes up topics beyond the lectures.

2 Learning objectives

Upon successful completion of the module, students have learned the approach, implementation and validation or investigation of interdisciplinary lighting issues. This requires an introduction into topics that go beyond the subject area of the lectures. Usually, this includes the selection of suitable illuminants, the development of electronic hardware, the use of photometric measuring instruments as well as the conception, execution and evaluation of studies. In addition, students learn to abstract questions, to develop research questions, to communicate information depending on the project, and to present and discuss results.

3 Recommended prerequisites for participation

Lighting Technology I-II, Project seminar Applications of Lighting Engineering

4 Form of examination

Module exam:
- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS

8 Grade bonus compliant to §25 (2)

9 References

Lecture notes of Lighting Technology I (Khanh); Lecture slides of our Laboratory; Book "LED Lighting: Technology and Perception" (Khanh et al., Wiley); Book „Farbwiedergabe" (Khanh et al., Pflaum-Verlag); specific literature depending on the topic, publications.

Courses

Course nr.	Course name		
18-kh-2053-pj	Project seminar Special Applications of Lighting Engineering		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Tran Quoc Khanh		Project seminar	3

Module name					
Project Seminar Wireless Communications					
Module nr. 18-kl-2040	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Anja Klein		

1 Teaching content

Solving special problems concerning wireless communications (problems concerning signal transmission and processing as well as problems concerning the network are possible, topics will be defined out of the current research topics of the lab);
working on the project in teams (2-3 students);
organizing and structuring of a project;
dealing with scientific publications, reading up the theoretical background of the task;
practical work on a complex task;
scientific presentation of the results (report/presentation);
defending the work in an oral discussion including an audience.

2 Learning objectives

After completion of the course, students possess

- the ability to classify and analyze special problems concerning wireless communications,
- the knowledge to plan and organize projects with temporal limitation,
- the capability to set up and test methodologies for analysis and simulation environments,
- skills to evaluate and present achieved results and achieved conclusions.

3 Recommended prerequisites for participation

Previous knowledge in digital communications, signal processing, wireless communication.

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS

8 Grade bonus compliant to §25 (2)

9 References

Literature will be announced during the course.

Courses

Course nr.	Course name		
18-kl-2040-pj	Project Seminar Wireless Communications		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Anja Klein, M.Sc. Sumedh Dongare		Project seminar	4

Module name					
Project Seminar Spintronic Devices					
Module nr. 18-me-2030	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Markus Meinert		

1 Teaching content

In the project seminar, students have the opportunity to deal with various aspects of spintronic devices. These range from the development of measurement systems for the characterization of spintronic devices, to the fabrication and characterization of functional thin film systems, to the lithographic preparation of spintronic sensor devices or memory cell (MRAM) prototypes. Students gain valuable insights into the entire chain of device fabrication from the deposition of atomically thin film systems to their basic characterization and lithography under clean room conditions.

2 Learning objectives

Students learn the basics of fabrication and application of spintronic devices as sensors or magnetic memory cells. Individual projects are carried out in small groups. The students deepen the material learned in the lectures in the form of a project work and learn and deepen their knowledge in the application of electronic measurement technology to answer concrete questions from research and development.

3 Recommended prerequisites for participation

- Introduction to Spintronics (desirable)
- Materials of Electrical Engineering (desirable)

4 Form of examination

Module exam:
- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. CE, M.Sc. iCE, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

Lecture notes Introduction to Spintronics (Meinert), subject-specific literature and publications.

Courses

Course nr.	Course name		
18-me-2030-pj	Project seminar Spintronic Devices		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Markus Meinert		Project seminar	3

Module name					
Project Seminar Emerging Topics in Sensor Array and Multichannel Processing					
Module nr. 18-pe-2040	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Marius Pesavento		

1	**Teaching content** This project-seminar addresses new trends in sensor array and multichannel processing with multidimensional tensor data representations. The specific thematic focus of the seminar will be adapted from year to year according to the latest trends in the research field. The topics will be announced on the course website well in advance.
2	**Learning objectives** Students will understand theory, algorithms and applications of sensor array and multichannel system.
3	**Recommended prerequisites for participation** Basic knowledge in linear algebra.
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral examination, Duration: 40 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. iCE, B.Sc. und M.Sc. iST, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**References** Harry L. Van Trees, Optimum Array Processing: Part IV of Detection, Estimation, and Modulation Theory, John Wiley & Sons, 2002. References include the latest scientific publications, seminars and books.

Courses

Course nr.	Course name		
18-pe-2040-pj	Project Seminar Emerging Topics in Sensor Array and Multichannel Processing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Marius Pesavento, M.Sc. Raphael Müller		Project seminar	4

Module name					
Project Seminar Emerging topics in MIMO Communication Networks					
Module nr. 18-pe-2050	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Marius Pesavento		

1	**Teaching content** This project-seminar addresses new trends in MIMO communications for the next generation of wireless communication systems. The specific thematic focus of the seminar will be adapted from year to year according to the latest trends in wireless communications. The topics will be announced on the course website well in advance.
2	**Learning objectives** Students will learn the fundamental concepts, procedures, theories, algorithms and applications of Massive MIMO systems and 5 G mobile communication networks by the latest scientific publications.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral examination, Duration: 40 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - KTS, M.Sc. iCE, B.Ed. etit, B.Sc. WI-etit, M.Sc. etit - VAS
8	**Grade bonus compliant to §25 (2)**
9	**References** References include the latest scientific publications, seminars and books.

Courses

Course nr.	Course name		
18-pe-2050-pj	Project Seminar Emerging Topics in MIMO Communication Networks		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Marius Pesavento		Project seminar	4

Module name					
Advanced Project Seminar Electromagnetic CAD					
Module nr. 18-sc-2020	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Sebastian Schöps		

1	**Teaching content** Work on a complex research-oriented project in numerical field calculation using commercial tools, in house software or self-written code.
2	**Learning objectives** Students will be able to simulate independently complex research-oriented engineering problems with numerical field simulation software. They are able to assess whether the project requires research and/or development and find the relevant literature on this independently. They know how to present the results on a scientific level in talks and a paper. Students are able to organize teamwork.
3	**Recommended prerequisites for participation** Good understanding of electromagnetic fields, knowledge about numerical simulation methods.
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. CE, M.Sc. etit - CMEE
8	**Grade bonus compliant to §25 (2)**
9	**References** Documents will be made available via Moodle if necessary.

Courses

Course nr.	Course name		
18-sc-2020-pj	Advanced Project Seminar Electromagnetic CAD		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sebastian Schöps		Project seminar	4

Module name Multimedia Communications Project Seminar II					
Module nr. 18-sm-2080	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Ralf Steinmetz		

1 Teaching 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

2 Learning objectives

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

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

3 Recommended prerequisites for participation

Keen interest to develop and explore challenging solutions and applications in cutting edge multimedia communications systems using scientific methods. Further we expect:

- Solid experience in programming Java and/or C (C/C++)
- Solid knowledge in object oriented analysis and design
- Basic knowledge of design patterns, refactoring and project management
- Solid knowledge in computer communication networks are recommended
- Lectures in Communication Networks I (II, III, or IV) are an additional plus

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

	Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**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) • Joshua Bloch: "Effective Java - Programming Language Guide" (ISBN-13: 978-0201310054) • Erich Gamma, Richard Helm, Ralph E. Johnson: "Design Patterns: Objects of Reusable Object Oriented Software" (ISBN 0-201-63361-2) • Martin Fowler: "Refactorings - Improving the Design of Existing Code" (ISBN-13: 978-0201485677) • Kent Beck: "Extreme Programming Explained - Embrace Changes" (ISBN-13: 978-0321278654)

Courses

Course nr.	Course name		
18-sm-2080-pj	Multimedia Communications Project Seminar II		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing. Julian Zobel, M.Sc. Fridolin Siegmund, Prof. Dr.-Ing. Ralf Steinmetz		Project seminar	3

<table>
<tr><td colspan="6">Module name
Advanced Project Seminar Energy Information Systems</td></tr>
<tr><td>Module nr.
18-st-2040</td><td>Credit points
6 CP</td><td>Workload
180 h</td><td>Self-study
135 h</td><td>Module duration
1 Term</td><td>Module cycle
Every Semester</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr. rer. nat. Florian Steinke</td></tr>
</table>

1	**Teaching content** Students elaborate on a research-oriented subject in the area of computer-systems in a self-responsible manner. They present a written documentation and/or a presentation of the acquired advanced knowledge. They provide a set of alternative solutions to a given problem.
2	**Learning objectives** After successful completion of the module, students will have learned to systematically develop alternative solutions to a posed problem, to critically question them and to implement goal-oriented decisions.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - CMEE
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
18-st-2040-pj	Advanced Project Seminar Energy Information Systems		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Florian Steinke		Project seminar	3

Module name					
Autonomous Driving Lab I					
Module nr. 18-su-2070	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1 Teaching content

During this module students gain practical experience in software development for embedded systems in the field of autonomous driving using a model car. In teamwork, they learn to cope with an extensive task. In order to solve this task they practice to use the theoretical knowledge available in the group (from other courses such as real-time systems, software engineering - introduction, C++ lab, digital control systems).

- Hands-on programming experience with C++ in the development of embedded software systems for autonomous driving based on a model car
- Application of control methods from the area of autonomous driving
- Application of software engineering techniques (design, documentation, test, ...) of a non-trivial embedded software system with hard real-time requirements and limited resources (memory, ...)
- Use of a given software framework and further libraries including a modular (real-time) operating system
- Hands-on experience using source code management systems, time management and other project management tools
- Presentations of the project results

2 Learning objectives

Students that have successfully participated in this module are able to organize and set-up a non-trivial software project in an interdisciplinary team according to a given problem independently. The participants acquire the following skills in detail:

- Independent familiarization with a given software framework and ready-made libraries
- Transfer of theoretic knowledge into a software system
- Extensive use of tools for version, configuration, and change management
- Realistic time and resource management (project management)
- Development of hardware/software systems with C++ considering important limitations of embedded systems
- Planning and implementation of extensive quality assurance measures
- Collaboration and communication in and between teams

3 Recommended prerequisites for participation

- ETiT/DT, iST, Informatik, WI-ET/DT: Basic software technology knowledge and advanced knowledge of object-oriented programming languages (especially C++)

Additionally desired:

- Basic knowledge of the development of real-time systems or image processing
- ETiT/AUT, MEC: Basic knowledge in control engineering including state space control design, some additional basic knowledge in digital control design may be helpful

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral examination, Duration: 30 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

	Module exam: • Module exam (Study achievement, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, M.Sc. etit - AUT, B.Sc. CE, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/ps-af-i and Moodle

Courses

Course nr.	Course name		
18-su-2070-pj	Autonomous Driving Lab I		
Instructor		**Type**	**SWS**
Dr. Ing. Eric Lenz, Dr. Ing. Stefan Tomaszek, Prof. Dr. rer. nat. Andreas Schürr		Project seminar	3

Module name					
Autonomous Driving Lab II					
Module nr. 18-su-2100	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1 Teaching content

- Further development and optimization of a robust C++ framework for solving non-trivial problems in the field of autonomous driving based on realistic challenges from the Carolo Cup, an international student competition for autonomous model cars
- Development and implementation of different algorithms (e.g., for motion planning, image processing, control, and obstacle avoidance) in an embedded system with hard real-time requirements and limited resources (memory, ...)
- Application and further development of control methods in the field of autonomous driving
- Application of software engineering techniques (design, documentation, testing, ...) for solving the problem
- Using source code management systems, time management and other project management tools
- Presentations of the project results

2 Learning objectives

Students learn to independently develop, implement and present new concepts and algorithms in the field of autonomous driving. Realistic problems from the Carolo Cup are solved with existing knowledge and skills practically and the implementation is ensured by quality assurance measures.

Students who have successfully participated in this project seminar are able to independently analyze and solve a complex and realistic task in the field of autonomous driving. The participants acquire the following skills in detail:

- Further development and optimization of an existing software system and the used algorithms independently
- Solving and implementation of non-trivial, realistic control engineering challenges
- Extensive use of tools for version, configuration, change, and quality assurance management
- Realistic time planning and resource allocation (project management)
- Further development and optimization of complex hardware/software systems under realistic environmental conditions
- Planning and implementation of extensive quality assurance measures
- Collaboration, communication and organization within the team

3 Recommended prerequisites for participation

Previous participation in the project seminar "Autonomous Driving I" or course with similar content.

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral examination, Duration: 30 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral examination, Weighting: 100 %)

7 Usability of the module

	M.Sc. MEC, M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, B.Sc. und M.Sc. iST			
8	**Grade bonus compliant to §25 (2)**			
9	**References** https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/ps-af-ii und Moodle			
Courses				
	Course nr. 18-su-2100-pj	**Course name** Autonomous Driving Lab II		
	Instructor Dr. Ing. Eric Lenz		**Type** Project seminar	**SWS** 3

Module name Project Seminar Terahertz Technology, Communication and Sensors					
Module nr. 18-pr-2030	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Sascha Preu		

1	**Teaching content** Investigating and solving specific problems concerning the development of Terahertz devices, of applications of THz technology as well as topics of the area of Optics and communication technology. The specific task will be defined based on current research topics. The project seminar includes working on a given task by one's own, organizing and structuring of a seminar task, searching and analyzing of scientific reference publications, summarizing achieved results and conclusions by means of a written report, presenting achieved results and conclusions and defending them in an oral discussion including audience. Topics include, e.g.: • Terahertz Optics • Optics/photonics • Spectroscopy • Semiconductor devices • Light-matter interaction
2	**Learning objectives** After completion of the course, students possess: • the ability to apply theoretical models to practical problems • deep and special knowledge in a particular field related to THz science, optics or semiconductor physics • the skills to find, analyze and evaluate scientific reference papers for a particular topic • the capability to summarize the achieved scientific findings in the form of a concise report, and to present and discuss achieved results in the form of a presentation in front of an audience
3	**Recommended prerequisites for participation** Previous knowledge in at least one of the following disciplines: Optics, semiconductor physics, or THz technology
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the project.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. CE, M.Sc. etit - KTS, M.Sc. iCE
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be announced once the topic is defined.
Courses	

	Course nr.	Course name		
	18-pr-2030-pj	Project Seminar Terahertz Technology, Communication and Sensors		
	Instructor		**Type**	**SWS**
	Prof. Dr. rer. nat. Sascha Preu		Project seminar	4

<table>
<tr><td colspan="6">Module name
Product Development Methodology III</td></tr>
<tr><td>Module nr.
18-sa-2010</td><td>Credit points
5 CP</td><td>Workload
150 h</td><td>Self-study
105 h</td><td>Module duration
1 Term</td><td>Module cycle
Winter term</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Ph.D. Thomas Burg</td></tr>
</table>

1	**Teaching 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** 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 prerequisites for participation** Product Development Methodology I
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - SAE, M.Sc. WI-etit, M.Sc. CE, M.Sc. MedTec, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Script: Development Methodology (PEM)

Courses

<table>
<tr><td>Course nr.
18-sa-2010-pj</td><td colspan="3">Course name
Product Development Methodology III</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Tran Quoc Khanh, Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr. Mario Kupnik, Prof. Ph.D. Thomas Burg</td><td>Type
Project seminar</td><td>SWS
3</td></tr>
</table>

Module name Product Development Methodology IV					
Module nr. 18-sa-2060	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Tran Quoc Khanh		

1	**Teaching 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** 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 prerequisites for participation** Product Development Methodology I
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - SAE, M.Sc. CE, M.Sc. MedTec, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Script: Development Methodology (PEM)

Courses

Course nr.	**Course name**		
18-sa-2060-pj	Product Development Methodology IV		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Tran Quoc Khanh, Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr. Mario Kupnik, Prof. Ph.D. Thomas Burg		Project seminar	3

Module name					
Project Seminar Hardware for Neural Networks					
Module nr. 18-zh-2020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language English			**Module owner** Prof. Dr.-Ing. Li Zhang		

1 Teaching content

Students will work on their own in this course. Topics and application context will be defined individually for each student. In this course hardware for neural networks will be investigated. This particularly means the improvement of software and hardware methods for efficient hardware for neural networks and the implementation of such hardware with commercial or open-source tools or FPGAs. Usually, the course starts with a literature search to get acquainted with the hardware for neural networks. This is followed by the practical part and finally the results are presented in a written report and a presentation.

2 Learning objectives

Successful students will know how to implement hardware for neural networks within a given application context. They can use tools to train a neural network and know how to realize it on a given hardware architecture. They are capable to evaluate the performance of an application.

3 Recommended prerequisites for participation

- Knowledge of neural network training and inference (cf. course hardware for neural network)
- Knowledge of digital or analog circuits (cf. course hardware for neural network)
- Solid programming skills (either in Python or VHDL depending on the application scenario)

4 Form of examination

Module exam:
- Module exam (Study achievement, Oral examination, Duration: 30 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Study achievement, Oral examination, Weighting: 100 %)

7 Usability of the module

M.Sc. etit - DT, M.Sc. WI-etit, M.Sc. CE, M.Sc. iCE, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

Will be given to the students during the individual seminar kick-off meeting.

Courses

Course nr.	Course name		
18-zh-2020-pj	Project Seminar Hardware for Neural Networks		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Li Zhang		Project seminar	3

Module name					
Project Seminar Biophotonics					
Module nr. 18-fr-2020	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr. habil. Torsten Frosch		

1 Teaching content

This module is based on practical work on current, promising and trend-setting topics in biophotonics. We focus on applications of optical spectroscopy and microscopy in medical technology. Students will gain a deeper insight into practical work with lasers, optics, spectrometers, microscopes, etc. Participation in current research projects are possible, depending on the number of participants. The experimental results are evaluated using advanced techniques and methods of data processing and statistics and are documented in reports following scientific standards.

2 Learning objectives

After successful completion of this module, students will be able to analyze and evaluate biophotonic methods and techniques. In addition, they have learned to plan and implement their own projects independently and collaborate in teams. They are able to apply experimental skills and advanced techniques and methods of data analysis. Depending on the task, students learn to independently analyze, improve, or build up optical setups from scratch. In addition, it is possible to program software for controlling devices and to analyze medically relevant samples. Furthermore, the measurement results are evaluated, presented, and interpreted in a scientific context. With the gained knowledge, students are able to critically analyze existing setups or instruments and develop their own approaches. In addition, students gain experience in preparing written reports according to scientific standards. They also practice presenting their work results to a professional or lay audience.

3 Recommended prerequisites for participation

Module Basics of Optics for Biomedical Engineering

4 Form of examination

Module exam:
- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. CE, M.Sc. MedTec, B.Sc. und M.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

Current scientific literature is recommended separately for the individual experiments. The following books can serve as a general reference:
- Kramme, Medizintechnik - Kapitel Biomedizinische Optik (Biophotonik), Springer
- Gerd Keiser, Biophotonics: Concepts to Applications, Springer
- Lorenzo Pavesi, Philippe M. Fauchet, Biophotonics, Springer
- Jürgen Popp, Valery V. Tuchin, Arthur Chiou, Stefan H. Heinemann, Handbook of Biophotonics, Wiley-VCH

Courses

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-fr-2020-pj</td><td colspan="3">Course name
Project Seminar Biophotonics</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. habil. Torsten Frosch</td><td>Type
Project seminar</td><td>SWS
4</td></tr>
</table>

2.5 Field Trip

Module name Railway Vehicle Engineering					
Module nr. 18-bt-2050	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Yves Burkhardt		

1	**Teaching content** From the comprehensive and interdisciplinary domain of the railway technology (vehicle technology, signal and safety technology, construction engineering and railway operating technology) the module picks out the domain of the automotive engineering with the emphasis of the mechanical part. It offers an interrelated introduction into selected chapters of the rail vehicle engineering with special emphasis in the railway-specific technical solutions and procedures. Theoretical basics as well as essential components of the rail vehicle are taught in depth.
2	**Learning objectives** After completing the module, students will have developed an understanding of the mechanical and mechanical engineering principles of modern rail vehicles.
3	**Recommended prerequisites for participation** Bachelor in Electrical Engineering, Mechatronics or Mechanical Engineering
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MEC, M.Sc. ESE, M.Sc. etit - EET, M.Sc. WI-etit, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** References/Textbooks: • Detailed textbook; Filipovic, Z: Elektrische Bahnen. Springer, Berlin, Heidelberg, 1995. • Obermayer, H.J.: Internationaler Schnellverkehr. Franckh-Kosmos, Stuttgart, 1994.

Courses

Course nr.	**Course name**		
18-bt-2050-vl	Railway Vehicle Engineering		
Instructor		**Type**	**SWS**
Dr.-Ing. Michael Karatas		Lecture	2

Module name Excursion SAE					
Module nr. 18-kn-1060	**Credit points** 1 CP	**Workload** 30 h	**Self-study** 30 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Teaching content** During the excursion SAE (duration 5 days) several companies working on electrical engineering and information technology and other fields will be visited. Students can become acquainted with close-to-reality examples. Working fields of an electrical engineer can be assessed, with technical- or organizational aspects and conditions of work as the main target. By the attendance of several companies in successive days, a comparison becomes possible. During the excursion the group is accommodated in e.g. hostels.
2	**Learning objectives** Upon completion of the module, students will understand and be able to concisely describe products and production processes in micro and precision engineering of relevant industrial companies.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Report, p/np RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Report, Weighting: 100 %)
7	**Usability of the module** B.Ed. etit, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
18-kn-1060-ek	Excursion SAE		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Tran Quoc Khanh, Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr. Mario Kupnik, Prof. Ph.D. Thomas Burg		Field trip	0

2.6 Colloquia

Module name Industrial Colloquium					
Module nr. 18-dt-2010	**Credit points** 2 CP	**Workload** 60 h	**Self-study** 30 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Ralf Steinmetz		

1	**Teaching content** Primary goal of this module is to get an overview of current trends in the ICT industry. Also, students shall be linked to industry representatives to improve chances for an internship or job opportunities. Additionally, students will get an impression of different ways to give a technical presentation.
2	**Learning objectives** Students that have successfully finished this module know various job types in the area of computer engineering. They can follow a technical presentation and they can summarize the presentation in their own words as a written report.
3	**Recommended prerequisites for participation** Mandatory: Basic knowledge in Information Systems and Commubnication Systems. The sutdent has to be capeable to understand the technical aspects and to summerize them in a written report as a short paper.
4	**Form of examination** Module exam: • Module exam (Study achievement, Report, Default RS) Report (including submission of programming code)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Report, Weighting: 100 %)
7	**Usability of the module** M.Sc. etit - DT, M.Sc. WI-etit, B.Sc. und M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
18-dt-2010-ko	Industrial Colloquium		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Florian Steinke, Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr.-Ing. Christian Hochberger, Prof. Dr. rer. nat. Andreas Schürr, Prof. Dr.-Ing. Ralf Steinmetz, Prof. Dr.-Ing. Li Zhang		Colloquium	2

2.7 Modules of the M.Sc. Biomedical Engineering

Please note that the modules of the Biomedical Engineering degree programs can only be selected by students of Biomedical Engineering.

<table>
<tr><td colspan="7">Module name
Clinical Requirements for Medical Imaging</td></tr>
<tr><td colspan="2">Module nr.
18-mt-2020</td><td>Credit points
3 CP</td><td>Workload
90 h</td><td>Self-study
60 h</td><td>Module duration
1 Term</td><td>Module cycle
Winter term</td></tr>
<tr><td colspan="4">Language
German</td><td colspan="3">Module owner
Prof. Dr. Thomas Vogl</td></tr>
<tr><td>1</td><td colspan="6">Teaching 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).</td></tr>
<tr><td>2</td><td colspan="6">Learning objectives
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.</td></tr>
<tr><td>3</td><td colspan="6">Recommended prerequisites for participation</td></tr>
<tr><td>4</td><td colspan="6">Form of examination
Module exam:
Module exam (Technical examination, Oral examination, Duration: 60 Min., Default RS)</td></tr>
<tr><td>5</td><td colspan="6">Prerequisite for the award of credit points
Passing the final module examination</td></tr>
<tr><td>6</td><td colspan="6">Grading
Module exam:
Module exam (Technical examination, Oral examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td colspan="6">Usability of the module
M.Sc. MedTec</td></tr>
<tr><td>8</td><td colspan="6">Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td colspan="6">References
Will be announced at the event</td></tr>
<tr><td colspan="7">Courses</td></tr>
</table>

	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	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. Thomas Vogl		

1	**Teaching 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** 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 prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 60 Min., Default RS) As a rule, the examination takes the form of a written exam (duration: 60 minutes). If up to 20 students register, the examination will be an oral group examination (duration: 20 minutes per person/per examination). The type of examination will be announced at the beginning of the course.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be announced at the event
Courses	

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

Module name Radiotherapy I					
Module nr. 18-mt-2040	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Dr. Jörg Licher		

1	**Teaching 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** 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 prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**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.	**Course name**		
18-mt-2040-vl	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	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Dr. Janett Köhn		

1 Teaching 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

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 prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

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

7 Usability of the module

M.Sc. MedTec

8 Grade bonus compliant to §25 (2)

9 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 Dr. Janett Köhn	**Type** Lecture	**SWS** 2

<table>
<tr><td colspan="6">Module name
Nuclear Medicine</td></tr>
<tr><td>Module nr.
18-mt-2060</td><td>Credit points
3 CP</td><td>Workload
90 h</td><td>Self-study
60 h</td><td>Module duration
1 Term</td><td>Module cycle
Winter term</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Dr. Christian Happel</td></tr>
</table>

1	**Teaching 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** 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 prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**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**	**SWS**
Dr. Christian Happel		Lecture	2

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	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Dr. Robert Sader		

1	**Teaching 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** 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 prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**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	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. Dr. Robert Sader		

1 Teaching 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

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 prerequisites for participation

Digital Dentistry and Surgical Robotics and Navigation I

4 Form of examination

Module exam:
- Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

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

7 Usability of the module

M.Sc. MedTec

8 Grade bonus compliant to §25 (2)

9 References

To be published during the event

Courses

Course nr.	Course name		
18-mt-2080-vl	Digital Dentistry and Surgical Robotics and Navigation II		
Instructor		**Type**	**SWS**
Prof. Dr. Dr. Robert Sader		Lecture	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	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Dr. Robert Sader		

1	**Teaching 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** 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 prerequisites 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 exam: • Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** To be published during the event.
Courses	

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

<table>
<tr><td colspan="6">Module name
Anesthesia I</td></tr>
<tr><td>Module nr.
18-mt-2100</td><td>Credit points
3 CP</td><td>Workload
90 h</td><td>Self-study
60 h</td><td>Module duration
1 Term</td><td>Module cycle
Winter term</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr. Dr. Kai Zacharowski</td></tr>
</table>

1	**Teaching 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** 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 prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

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

Module name					
Clinical Aspects ENT & Anesthesia II					
Module nr. 18-mt-2110	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. Dr. Kai Zacharowski		

1	**Teaching 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** 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 prerequisites for participation** "Anesthesia I"
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 60 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** Boenninghaus, H.-G., Lenarz, T. (2012) Otorhinolaryngology. Springer.
Courses	

	Course nr.	Course name		
	18-mt-2110-vl	Clinical Aspects ENT & Anesthesia II		
	Instructor		**Type**	**SWS**
	Prof. Dr. Dr. Kai Zacharowski		Lecture	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	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Timo Stöver		

1	**Teaching 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** 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 prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 60 Min., Default RS) 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	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**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**	**SWS**
	Prof. Dr. Timo Stöver		Lecture	2

Module name Basics of Medical Information Management					
Module nr. 18-mt-2130	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr. Holger Storf		

1 Teaching 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

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 prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, p/np RS)

The type of examination will be announced in the first lecture. Possible types include presentation (30 minutes), documentation, report.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. MedTec

8 Grade bonus compliant to §25 (2)

9 References

Courses

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

Module name Technical Performance Optimization of Radiological Diagnostics					
Module nr. 18-mt-2140	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Thomas Vogl		

1	**Teaching 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** 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 prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) The examination form will be announced at the beginning of the course. Possible paths are presentation (25 min), report.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be announced at the event

Courses

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

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	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Dr. Jörg Licher		

1	**Teaching 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** 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 prerequisites for participation** Radiotherapy I; Nuclear Medicine
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral examination, Duration: 30 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be announced at the beginning of the course.

Courses

Course nr.	**Course name**		
18-mt-2150-se	Seminar Radiation Physics and Technology in Medicine		
Instructor Dr. Jörg Licher		**Type** Seminar	**SWS** 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	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Dr. Robert Sader		

1	**Teaching content** The module 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** 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 prerequisites for participation** Concomitant participation in the module „Digital Dentistry and Surgical Robotics and Navigation I" is recommended.
4	**Form of examination** Module exam: • Module exam (Technical examination, Colloquium, Duration: 20 Min., p/np RS) The colloquium takes place during the internship in the context of scientific discussions on the contents of the weekly units. The module is considered to have been passed if the student has attended a time portion of usually 80% of the course offerings and has participated in the scientific discourse on the contents of the weekly units. The qualification goals of the module, e.g. clinical application of various procedures, familiarization with medical device technologies, the performance of practical exercises and clinical demonstration on patients, can only be achieved through regular participation in the internship.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Colloquium, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**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		Lab	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	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. Dr. Robert Sader		

1	**Teaching content** The module 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** 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 prerequisites for participation** Concomitant participation in the module „Digital Dentistry and Surgical Robotics and Navigation II" is recommended.
4	**Form of examination** Module exam: • Module exam (Technical examination, Colloquium, Duration: 20 Min., p/np RS)
5	**Prerequisite for the award of credit points** Passing the module The module is passed if the final module examination has been passed and the student has attended 80% of the courses offered. The qualification objectives of the module, e.g. clinical application of various procedures, familiarization with medical device technologies, the performance of practical exercises and clinical demonstration on patients, can only be achieved through regular participation in the practical course. **Please note:** Attendance regulation according to the framework regulations of Goethe University Frankfurt am Main.
6	**Grading** Module exam: • Module exam (Technical examination, Colloquium, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** To be published during the event.

Courses				
	Course nr. 18-mt-2170-pr	**Course name** Internship in Surgery and Dentistry II		
	Instructor Prof. Dr. Dr. Robert Sader		**Type** Lab	**SWS** 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	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Dr. Robert Sader		

1 Teaching content

The module 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

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 prerequisites for participation

Concomitant participation in the module „Digital Dentistry and Surgical Robotics and Navigation III" is recommended.

4 Form of examination

Module exam:

- Module exam (Technical examination, Colloquium, Duration: 20 Min., p/np RS)

The colloquium takes place during the internship in the context of scientific discussions on the contents of the weekly units.

The module is considered to have been passed if the student has attended a time portion of usually 80% of the course offerings and has participated in the scientific discourse on the contents of the weekly units. The qualification goals of the module, e.g. clinical application of various procedures, familiarization with medical device technologies, the performance of practical exercises and clinical demonstration on patients, can only be achieved through regular participation in the internship.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Technical examination, Colloquium, Weighting: 100 %)

7 Usability of the module

M.Sc. MedTec

8 Grade bonus compliant to §25 (2)

9 References

	To be published during the event.

Courses

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

Module name Internship "Medicine Live“					
Module nr. 18-mt-2190	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Dr. Kai Zacharowski		

1	**Teaching 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** 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 prerequisites for participation** Competencies from the "Anesthesia I & II" modules.
4	**Form of examination** Module exam: • Module exam (Study achievement, Presentation, Duration: 20 Min., p/np RS) 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	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Presentation, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References**
Courses	

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-mt-2190-pr</td><td colspan="3">Course name
Internship "Medicine Live“</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. Timo Stöver, Prof. Dr. Dr. Kai Zacharowski</td><td>Type
Lab</td><td>SWS
2</td></tr>
</table>

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	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Christof Mandry		

1	**Teaching 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** 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 prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Duration: 60 Min., Default RS) 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	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References**
Courses	

	Course nr.	Course name		
	18-mt-2200-vl	Introduction to Ethics: The Example of Medical Ethics		
	Instructor		**Type**	**SWS**
	Prof. Dr. Christof Mandry		Lecture	2

Module name Current Issues in Medical Ethics					
Module nr. 18-mt-2210	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. Christof Mandry		

1	**Teaching 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** 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 prerequisites for participation** A basic understanding of ethics and / or medical ethics is desirable.
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) 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	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

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

<table>
<tr><td colspan="6">Module name
Anthropological and Ethical Issues of Digitization</td></tr>
<tr><td>Module nr.
18-mt-2220</td><td>Credit points
3 CP</td><td>Workload
90 h</td><td>Self-study
60 h</td><td>Module duration
1 Term</td><td>Module cycle
Summer term</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr. Christof Mandry</td></tr>
</table>

<table>
<tr><td>1</td><td>Teaching 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.</td></tr>
<tr><td>2</td><td>Learning objectives
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.</td></tr>
<tr><td>3</td><td>Recommended prerequisites for participation</td></tr>
<tr><td>4</td><td>Form of examination
Module exam:
• Module exam (Study achievement, Oral examination, Default RS)
The type of examination will be announced in the first lecture. Possible types include presentation (20 minutes), moderation or oral examination.</td></tr>
<tr><td>5</td><td>Prerequisite for the award of credit points
Passing the final module examination</td></tr>
<tr><td>6</td><td>Grading
Module exam:
• Module exam (Study achievement, Oral examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td>Usability of the module
M.Sc. MedTec</td></tr>
<tr><td>8</td><td>Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td>References</td></tr>
<tr><td colspan="2">Courses</td></tr>
</table>

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

Module name Medical Data Science					
Module nr. 18-mt-2230	**Credit points** 2 CP	**Workload** 60 h	**Self-study** 45 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** Prof. Dr. Holger Storf		

1	**Teaching 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** **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 prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Written examination, Default RS) The type of examination will be announced in the first lecture. Possible types include reports or protocols.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**References** Recent publications of the speakers (will be announced)
Courses	

Course nr.	Course name		
18-mt-2230-ko	Medical Data Science		
Instructor		**Type**	**SWS**
		Colloquium	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	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** Prof. Dr. Holger Storf		

1	**Teaching 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** 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 prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Details of the exam will be announced at the beginning of the course [presentation (30 minutes) and report].
5	**Prerequisite for the award of credit points** Passing the module The module is passed if the final module examination has been passed and the student has attended 80% of the courses offered. The qualification objectives of the module can only be achieved through regular participation in the seminar. **Please note:** Attendance regulation according to the framework regulations of Goethe University Frankfurt am Main.
6	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. MedTec
8	**Grade bonus compliant to §25 (2)**
9	**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**
	Prof. Dr. Holger Storf		Seminar	2

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	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr. Holger Storf		

1 Teaching 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

- 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 prerequisites for participation

4 Form of examination

Module exam:
- Module exam (Study achievement, Oral/written examination, Default RS)

The type of examination will be announced in the first lecture. Possible types include presentation (30 minutes), documentation.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:
- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. MedTec

8 Grade bonus compliant to §25 (2)

9 References

Will be announced during the project seminar.

Courses

Course nr.	Course name	
18-mt-2250-pj	Project seminar „Medical Data Science - Medical Informatics“	
Instructor	**Type**	**SWS**
Prof. Dr. Holger Storf	Project seminar	4

2.8 Mandatory modules of M.Sc. programs from other departments

Module name Introduction to Business Administration						
Module nr. 01-10-1028/f		**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German				**Module owner** Prof. Dr. rer. pol. Dirk Schiereck		
1	**Teaching 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** 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 prerequisites for participation** None					
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)					
5	**Prerequisite for the award of credit points** Passing the examination					
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)					
7	**Usability of the module**					
8	**Grade bonus compliant to §25 (2)**					
9	**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.					

<table>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
01-10-0000-vl</td><td colspan="3">Course name
Introduction to Business Administration</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Lecture</td><td>SWS
2</td></tr>
</table>

Module name Introduction to Innovation Management					
Module nr. 01-22-2B01	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language English			**Module owner** Prof. Dr. Alexander Kock		

1	**Teaching 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** 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 prerequisites for participation** Prerequisites: none Previous Knowledge: see initial skills and basics in business administration
4	**Form of examination** Module exam: • Module exam (Technical examination, Written examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the Examination
6	**Grading** Module exam: • Module exam (Technical examination, Written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. Wirtschaftsingenieurwesen, B.Sc. Wirtschaftsinformatik
8	**Grade bonus compliant to §25 (2)**
9	**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** Introduction to Innovation Management		
	Instructor Prof. Dr. Alexander Kock		**Type** Lecture	**SWS** 2

Module name Introduction to Entrepreneurship					
Module nr. 01-27-1B01	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 45 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language English			**Module owner** Prof. Dr. rer. pol. Carolin Bock		

1	**Teaching 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** 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 prerequisites for participation** Prerequisites: none Previous Knowledge: see initial skills and basics in business administration
4	**Form of examination** Module exam: • Module exam (Technical examination, Written examination, Duration: 60 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the Examination
6	**Grading** Module exam: • Module exam (Technical examination, Written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. Wirtschaftsingenieurwesen, B.Sc. Wirtschaftsinformatik
8	**Grade bonus compliant to §25 (2)**
9	**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.	Course name		
01-27-1B01-vl	Introduction to Entrepreneurship		
Instructor		**Type**	**SWS**
Prof. Dr. rer. pol. Carolin Bock		Lecture	3

Module name Introduction to project management					
Module nr. 01-19-0B03	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr. rer. pol. Andreas Pfnür		

1	**Teaching content** Basic concepts, project organisation, planning a work breakdown structure, quantity and cost estimation, time, cost and capacity planning, project control, project risk management, financial planning of projects, selected problems of project leadership, Selected applications and case studies from project management
2	**Learning objectives** After the course students are able to • understand the basic tasks and challenges of project management, • know different alternatives of the organization of the project management and to evaluate their specific advantages and disadvantages, • demonstrate the various ways in which project committees can be set up and how they can be integrated into a company's organisation, • understand and develop a project structure plan, • understand and evaluate the procedures for estimating quantities and project costs, • apply and evaluate state-of-the-art models and procedures for time, cost and resource planning, • carry out in-depth procedures of project controlling and to learn how to apply them in specific situations. • understand the basics of financial planning of a project. • understand selected problems of project management.
3	**Recommended prerequisites for participation** Prerequisites: none Previous Knowledge: see initial skills
4	**Form of examination** Module exam: • Module exam (Technical examination, Written examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the examination
6	**Grading** Module exam: • Module exam (Technical examination, Written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. Wirtschaftsingenieurwesen, B.Sc. Wirtschaftsinformatik
8	**Grade bonus compliant to §25 (2)**
9	**References**

	Burghardt, M. (2008): Projektmanagement. Leitfaden für die Planung, Überwachung und Steuerung von Projekten (8., überarb. und erw. Aufl.). Erlangen: Publicis Corp. Publ. Kerzner, H. (2006): Project Management - A Systems Approach to Planning, Scheduling, and Controlling (9. Aufl.). Hoboken, NJ: Wiley. Madaus, B. (2000): Handbuch Projektmanagement (6., überarb. und erw. Aufl.). Stuttgart: Schäffer-Poeschel. Schwarze (2001) Projektmanagement mit Netzplantechnik, Herne, 8. Auflg. Further literature will be announced in the lecture.

Courses

Course nr.	Course name		
01-19-5100-vu	Introduction to Project Management		
Instructor		**Type**	**SWS**
Prof. Dr. rer. pol. Andreas Pfnür		Lecture and practice	2

Module name Introduction to Economics (V)					
Module nr. 01-60-1042/f	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr. rer. pol. Michael Neugart		

1	**Teaching 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** Students are introduced to the principles of economics and their application to selected fields of interest.
3	**Recommended prerequisites for participation** None
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** none
8	**Grade bonus compliant to §25 (2)**
9	**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 Chemistry for Energy Scientists and Engineers					
Module nr. 07-03-0305	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 150 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. rer. nat. Ulrike Kramm		

1	**Teaching content** Scientific fundamentals for chemical processes: Chemical thermodynamics; Ideal and real mixtures; Phase diagrams; Chemical kinetics; Catalysis; Electrochemistry. Chemistry of fuels. Knowledge of inorganic substances and materials relevant for energy conversion and the efficient usage of energy: Synthesis of characterization of solids; Oxides; Refractory materials; Ionic conductors; Electrode materials; Physical properties.
2	**Learning objectives** Students gain basic knowledge in fundamentals of chemistry and chemical processes. They develop an understanding of the principles and methods in chemistry. They understand the difference between classes of substances like organic fuels and inorganic materials for energy conversion. They know about general methods of chemical synthesis and characterization. They are capable to continue participating in advanced courses in chemistry.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Default RS) Fachprüfung: Written exam 90 min. / Oral exam 30 min.
5	**Prerequisite for the award of credit points** Modulabschlussleistung: Fachprüfung
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. Energy Science and Engineering
8	**Grade bonus compliant to §25 (2)**
9	**References** To be announced in the lecture.

Courses

Course nr.	**Course name**	**Instructor**	**Type**	**SWS**
07-03-0301-vl	Chemistry for Energy Scientists and Engineers		Lecture	0
07-03-0301-ue	Übung Chemistry for Energy Scientists and Engineers		Practice	0

Module name Materials Science for Renewable Energy Systems					
Module nr. 11-01-4404	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Oliver Gutfleisch		

1	**Teaching content** • Introduction • Materials Criticality • Classifications of materials according to their physical properties • Structural Properties • Defects - Gutfleisch • Electronic properties I • Electronic properties II • Semiconductors • Solar Cells • Batteries and Fuel Cells • Dielectrics • Thermoelectrics • Magnetic Materials for Energy Applications I: Hard and soft Magnets for wind energy and E-mobility • Magnetic Materials for Energy Applications II: Solid state cooling
2	**Learning objectives** General context is the recognition that the great transformation to renewable energy technologies is also a material transformation; in other words, the criticality of technology metals (introduced in the course) will affect the speed of the transformation. The basic concepts of materials science will be introduced with a main emphasis of physical properties as dependent of material's composition and microstructure, as well as defects, and on the combinations of materials. Selection criteria based on some initial understanding of some fundamental physics concepts such as various types of conductivity and electric properties for the application of materials will be developed for typical energy applications. The students should develop the competences to correlate basic materials properties and engineering strategies for various energy conversion devices (disciplinary expertise). They should be able to judge results from literature and news from media, and understand limitations and perspectives of given research approaches and technology developments (interdisciplinary expertise).
3	**Recommended prerequisites for participation** None
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS) Module Examination (Technical Examination, Written Exam, Duration 90 min, Standard)
5	**Prerequisite for the award of credit points** passing of exam
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** Master of Science Energy Science and Engineering
8	**Grade bonus compliant to §25 (2)**
9	**References**

M.F. Ashby and D.R.H. Jones, Engineering materials, Volumes I and II, Butterworth-Heinemann, Oxford UK (2006)
William D Callister Jr, David G. Rethwisch, Fundamentals of Materials Science and Engineering -An Integrated Approach, Third Edition, John Wiley &Sons, 2008
G. Gottstein, Physikalische Grundlagen der Materialkunde, Springer, also available in English: G. Gottstein, Physical Foundations of Material Science, Springer
Charles Kittel, Introduction to solid state physics, 8th edition, Wiley&Sons
R. O'Handley, Modern Magnetic Materials, John Wiley &Sons, 2000,
J.M.D. Coey: Magnetism and Magnetic Materials, Cambridge University Press, 2010
Safa O. Kasap, Principles of Electronic Materials and Devices, McGraw-Hill, 3rd edit., 2005 H. Julian Goldsmid, Introduction to Thermoelectricity, Springer Series in Materials Science, Vol. 121, 2009

Courses

Course nr.	**Course name**		
11-01-4404-vl	Materials Science for Renewable Energy Systems		
Instructor		**Type** Lecture	**SWS** 2

Course nr.	**Course name**		
11-01-4404-ue	Exercises Materials Science for Renewable Energy Systems		
Instructor		**Type** Practice	**SWS** 1

<table>
<tr><td colspan="6">Module name
Energy Technologies in Civil Engineering and Architecture</td></tr>
<tr><td>Module nr.
13-C0-M025</td><td>Credit points
5 CP</td><td>Workload
150 h</td><td>Self-study
120 h</td><td>Module duration
1 Term</td><td>Module cycle
Every 2. Semester</td></tr>
<tr><td colspan="3">Language
English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Ulrich Knaack</td></tr>
</table>

1	**Teaching content** - Basics of sustainable construction / buildings and urban planning - Building physics - Passive and active systems for energy efficiency and building services - Energy efficient area concepts - Political and societal framework conditions - Case examples
2	**Learning objectives** Students develop a basic understanding of energy efficiency and energy technologies in construction, both in the building and urban context, taking into account technical, economic, social and environmental aspects. They are familiar with the concepts of sustainable construction, building physics, active and passive building systems and energy-efficient construction in buildings as well as in housing areas and districts. Students have the ability to weigh up different solutions, to explain them objectively and understandably, to make decisions and give reasons for them. Students are able to present the results of their work iin a suitable form.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 90 Min., Default RS) • Module exam (Study achievement, Homework, worksheet, p/np RS) Study Examination: preparation of a project description and discussion
5	**Prerequisite for the award of credit points** Passing the module examination(s)
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 1) • Module exam (Study achievement, Homework, worksheet, Weighting: 0)
7	**Usability of the module** M.Sc. Energy Science and Engineering
8	**Grade bonus compliant to §25 (2)**
9	**References** Literature will be announced in the course.

Courses

Course nr.	Course name	
13-C0-0038-vl	Energy Technologies in Civil Engineering and Architecture	
Instructor	**Type**	**SWS**
	Lecture	2

Module name Energy Technologies in Mechanical Engineering					
Module nr. 16-13-6420	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Christian Hasse		

1	**Teaching content** Technical thermodynamics, state values and equations of state for gases, types of energy, 1. and 2. Law of thermodynamics, exergy and anergy, cyclic processes in thermodynamics, design of power plant processes
2	**Learning objectives** On successful completion of this module, students should be able to: 1. Explain and make use of the relationship between thermal and caloric state properties and state values. 2. Distinguish and define the different types of energies (e.g. work, heat, internal energy, enthalpy). 3. Analyse technical systems and processes by setting up energy balances and using equations of state. 4. Evaluate the quality of energy transfer processes by using entropy balances and looking at exergy. 5. Characterize the thermal behavior of gases, liquids and solid bodies as well as their respective phase changing processes. 6. Make use of this knowledge to analyze and describe machines (turbines, pumps etc.) and energy transfer processes (internal combustion engines, steam power plants, refrigerators, heat pumps).
3	**Recommended prerequisites for participation** Basic knowledge in mathematics and physics.
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Default RS) Oral (20 min) or written exam (90 min)
5	**Prerequisite for the award of credit points** Passing the examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. Energy Science and Engineering
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture slides available via TUCaN. Book: P. Stephan, K. Schaber, K. Stephan, F. Mayinger: Thermodynamik Bd. 1 Einstoffsysteme, Springer 2005

Courses

Course nr.	**Course name**		
16-13-6420-vl	Energy Technologies in Mechanical Engineering		
Instructor		**Type** Lecture	**SWS** 2

	Course nr.	Course name		
	16-13-6420-ue	Energy Technologies in Mechanical Engineering		
	Instructor		**Type**	**SWS**
			Practice	2

Module name					
TK3: Ubiquitous / Mobile Computing					
Module nr. 20-00-0120	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. rer. nat. Eberhard Mühlhäuser		

1	**Teaching content** Objectives: - Knowledge of technical basics of the mobile communication - Knowledge of important challenges of the Ubiquitous Computing - Methodic knowledge about current approaches to these challenges Course Content: - Introduction to Ubiquitous Computing - Mobile Communication - Internet of Things: RFID and Smart Items - Service Discovery & Cloudlets - Context- and Location-aware Computing - Human Computer Interaction - Privacy and Trust in Ubiquitous Computing
2	**Learning objectives** After successfully attending the course, students are familiar with the technical basis of mobile communication. They understand the fundamental challenge of ubiquitous computing. They know current approaches to solve these challenges. They are able to apply their knowledge to build ubiquitous computing systems.
3	**Recommended prerequisites for participation** Computer Netzwerke and Distributed Systems
4	**Form of examination** Course related exam: • [20-00-0120-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0120-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the 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.
8	**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.
9	**References** Literature recommendations will be updated regularly, an example might be: A Primary Literature: Handbook of Research: Ubiquitous Computing Technology for Real Time Enterprises edited by Prof. Dr. Max Mühlhäuser, Dr. Iryna Gurevych, 2008, Information Science Reference, ISBN-10: 1599048329 B Secondary Literature: 1. F. Adelstein, S. Gupta et al.: Fundamentals of Mobile & Pervasive Computing McGraw Hill 2004, 2. Stefan Poslad: Ubiquitous Computing, Wiley 2009, ISBN 978-0-470-03560-3 3. Kapitel Mobilkommunikation: M. Sauter: Grundkurs Mobile Kommunikationssysteme: UMTS, HSDPA und LTE, GSM, GPRS und Wireless LAN; Vieweg-Teubner Studium 2010 4. J. Krumm (Ed.): Ubiquitous Computing Fundamentals, CRC Press 2010 D. Cook, S. Das (Ed.): Smart Environments, Wiley 2005

Courses

Course nr.	Course name		
20-00-0120-iv	TK3: Ubiquitous / Mobile Computing		
Instructor		**Type** Integrated course	**SWS** 4

Module name					
Algorithms for Electronic Design Automation Tools					
Module nr. 20-00-0183	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1	**Teaching content** - The VLSI design problem - Fundamental graph representations and algorithms - Representations for hierarchical circuits - Fabrication technologies for integrated circuits - Layout compaction - Timing analysis - Heuristical optimization techniques - Placement problems, algorithms, and cost functions - Exact optimization techniques - Partitioning and its use in placement - Floorplanning problems, representations, and techniques - Routing problems, algorithms, and cost functions
2	**Learning objectives** After successfully attending the course, the students know a number of fabrication technologies for integrated circuits. They are able to deduce from the technologies the requirements on automation tools for the different tasks in the design and realization process. They are familiar with modeling technological problems by formal concepts such as graphs and equation systems. They understand fundamental techniques for solving even hard computational problems and are able to apply these, together with knowledge of representative EDA algorithms, to develop new or refined implementations of design tools.
3	**Recommended prerequisites for participation** Recommended: Participation of lecture “Digitaltechnik", “Algorithmen und Datenstrukturen” and “Funktionale und objektorientierte Programmierung”.
4	**Form of examination** Course related exam: • [20-00-0183-vl] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0183-vl] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the 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.
8	**Grade bonus compliant to §25 (2)**
9	**References** Literature reommendations will be updated regularly, an example might be: Gerez: Algorithms for VLSI Design Automation Wang/Chang/Cheng: Electronic Design Automation

Courses

Course nr.	Course name		
20-00-0183-vl	Algorithms for Chip Design Tools		
Instructor		**Type** Lecture	**SWS** 2

Module name
Labs on Algorithms for Electronic Design Automation Tools

Module nr.	Credit points	Workload	Self-study	Module duration	Module cycle
20-00-0571	6 CP	180 h	120 h	1 Term	Winter term

Language	Module owner
German/English	Prof. Dr.-Ing. Andreas Koch

1 Teaching content
- Realizing Electronic Design Automation tools for layout synthesis, specifically for topics such as timing analysis, placement, and routing
- Evaluation of the quality-of-results and compute/memory requirements of developed tools in comparison to existing implementations

2 Learning objectives
After successfully attending the course, the students can independently implement Electronic Design Automation tools for the specified fabrication technology. They can evaluate their tools according to a number of quality metrics and perform a comparison with existing implementations.

3 Recommended prerequisites for participation
Recommended:
Participation of lecture "Algorithmen für Hardware-Entwurfswerkzeuge".

4 Form of examination
Course related exam:
- [20-00-0571-pr] (Study achievement, Oral/written examination, Default RS)

5 Prerequisite for the award of credit points
Pass exam (100%)

6 Grading
Course related exam:
- [20-00-0571-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the 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.

8 Grade bonus compliant to §25 (2)

9 References
Given scientific Papers to recommeded base-methods.

Courses

	Course nr.	Course name		
	20-00-0571-pr	Labs on Algorithms for Electronic Design Automation Tools		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Andreas Koch		Lab	4

Module name					
Architecture and Design of Computer Systems					
Module nr. 20-00-0012	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. phil. nat. Marc Fischlin		

1	**Teaching content** - Technological foundations and trends in micro electronics - Design flows for microelectronic systems - Description of hardware systems - Characteristics of computing systems - Architectural support for parallel execution - Memory systems - Heterogeneous systems-on-chip - On-chip and off-chip communication structures - Embedded systems, including in context of cyber-physical systems
2	**Learning objectives** After successfully attending the course, students are familiar with functional and non-functional requirements for heterogeneous discrete and integrated computing systems. They understand the techniques for realizing such systems and can use design methods and tools to apply the techniques to independently implement computing systems (or components thereof) that fulfill the given requirements. They are able to evaluate computing systems in a number of quality metrics.
3	**Recommended prerequisites for participation** Recommended: Pass of lecture „Digitaltechnik“ and „Rechnerorganisation“, respectively according knowledge.
4	**Form of examination** Course related exam: • [20-00-0012-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0012-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the 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.
8	**Grade bonus compliant to §25 (2)**
9	**References**

	Literature recommendations will be updated regularly, an example might be: Nikhil/Czeck: Bluespec by Example Arvind/Nikhil/Emer/Vijayaraghavan: Computer Architecture: A Constructive Approach Hennessy/Patterson: Computer Architecture - A Quantitative Approach Crockett/Elliott/Enderwitz/Stewart: The Zynq Book Flynn/Luk: Computer System Design Sass/Schmidt: Embedded Systems Design

Courses

Course nr.	**Course name**		
20-00-0012-iv	Architecture and Design of Computer Systems		
Instructor		**Type** Integrated course	**SWS** 3

Module name Introduction to Compiler Construction					
Module nr. 20-00-0904	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. phil. nat. Marc Fischlin		

1	**Teaching content** - Structure of compilers - Context-free grammars for the description of language syntax - Lexing and parsing techniques - Intermediate representations - Semantic analysis - Run-time organisation - Code generation - Software tools for compiler constructions - Implementation techniques for compilers
2	**Learning objectives** After successfully attending the course, students are familiar with the structure of compilers. They understand formal concepts for the description of syntax and semantics of programming languages. They can combine these concepts with algorithmic techniques to independently construct a compiler that maps a specified programming language to a given target machine. They know software tools supporting the construction of compilers and can apply these together with manual techniques to implement the compilers.
3	**Recommended prerequisites for participation** Recommended: Participation of lecture "Algorithmen und Datenstrukturen", "Funktionale und objektorientierte Programmierung" and "Rechnerorganisation", respectively according knowledge.
4	**Form of examination** Course related exam: • [20-00-0904-iv] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%) Course achievement may be acquired through exercises, hands-on training, programming and successfull discussion on colloquiums. Each area must be passed.
6	**Grading** Course related exam: • [20-00-0904-iv] (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. Informatik B.Sc. Informationssystemtechnik May be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References** Literature recommendations will be updated regularly, an example might be: Watt/Brown: Programming Language Processors in Java
Courses	

	Course nr.	Course name		
	20-00-0904-iv	Introduction to Compiler Construction		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Andreas Koch		Integrated course	3

Module name Compiler Tooling					
Module nr. 20-00-1013	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1	**Teaching content** Modern compilers are primarily designed to produce efficient code for a particular platform and in doing so they employ sophisticated analysis and transformation tools. Such an infrastructure is useful also for source code transformation, e.g. for tools to annotate, instrument, or canonicalize codes. The complexity of C++ makes the development of such tools a challenging task. An open compiler infrastructure used in a variety of research and production compilers is the LLVM infrastructure (www.llvm.org). A well-established front-end for C, C++ and objective C is Clang, which provides powerful mechanisms for extracting information from an abstract syntax tree representation of the underlying code, and thus enables source code modifications as well as the generation of the LLVM intermediate representation. The students will work with different components and techniques of the Clang/LLVM framework and implement practical exercises for source transformation. The Clang/LLVM techniques include, in particular, handling and matching of the Clang abstract syntax tree. Examples for source transformation will highlight various facets of code augmentation or refactoring, e.g. for instrumenting parallel codes, for passing information between the static analysis and runtime environment of (parallel) codes, or for code refactoring to conform to coding standards.
2	**Learning objectives** After attending this course, the students know basic and advanced concepts of syntactic and semantic code analysis and source transformation for C++, based on the Clang/LLVM technology. In particular, they can design and implement custom static analysis and code transformation tools using the Clang/LLVM framework, reflect and decide on the appropriate level of abstraction of the code representation for the task at hand, and synthesize additional usage scenarios for compiler technology.
3	**Recommended prerequisites for participation** Lecture Introduction to Compiler Construction (EiCB), Lecture System- and Parallel Programming (SPP), Knowledge of C++
4	**Form of examination** Course related exam: • [20-00-1013-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1013-pr] (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References**

<table>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
20-00-1013-pr</td><td colspan="3">Course name
Compiler Tooling</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Andreas Koch</td><td>Type
Lab</td><td>SWS
4</td></tr>
</table>

Module name Machine Dynamics					
Module nr. 16-98-4094	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Tobias Melz		

1	**Teaching content** Vibration Systems in Mechanical Engineering. Problems of Advanced Machine Dynamics. Elements (parameter) of mechanical vibration systems in machines and structures. Modelling and equations of motion of linear vibration systems for machines and structures. Input-output relations, excitation and vibration response signals in the time and frequency domain. Natural vibrations of linear SDOF- and MDOF systems, eigenvalues and eigenvectors, orthogonality. Forced vibrations of linear SDOF- and MDOF systems due to different excitations. Influence of (multiphysical) interactions (structure, fluid, electric and magnetic fields) on the vibration behavior. Vibration monitoring and diagnosis. Measures for vibration control. Vibration systems with distributed parameters (continua) and nonlinear vibrations. Applications of Machine Dynamics in different areas of Mechanical Engineering.
2	**Learning objectives** On successful completion of this module, students should be able to: 1. Work on basic problems in machine and structural dynamics and to find practical solutions. 2. Model real mechanical vibration systems (machines and structures) and to derive the equations of motion based on the principles of mechanics. 3. Determine and to analyse the dynamic characteristics (natural frequencies, damping behavior, vibration modes) of machines and structures. 4. Calculate forced vibrations (system responses) of machines and structures due to different types of excitations and to interpret the solutions. 5. Fundamentally recognize, to plan and to evaluate experimental investigations of vibration systems (frequency response, system identification, modal analysis). 6. Plan vibration monitoring and diagnosis for machines. 7. Suggest and to apply measures for vibration control.
3	**Recommended prerequisites for participation** Technical Mechanics I to III (Statics, Elastomechanics, Dynamics) and Mathematics I to III recommended.
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 150 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the examination.
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** Master MB Ia Grundlagen Master MB SP FAS WPB Ia Pflicht WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik) WI/MB, Master Mechatronik
8	**Grade bonus compliant to §25 (2)**

9	**References** Markert, R.: „Strukturdynamik", Shaker, 2013. Dresig, H.; Holzweißig, F.: „Maschinendynamik", 10. Auflage, Springer, 2011. Gasch, R.; Nordmann, R.: „Rotordynamik“, 2. Auflage, Springer,2005. Dresig, H.: „Schwingungen mechanischer Antriebssysteme“, Springer 2001. Fischer, U.; Stephan, W.: „Mechanische Schwingungen“, 3. Auflage, Fachbuchverlag Leipzig, 1993.

Courses

Course nr.	Course name		
16-98-4094-vl	Machine Dynamics		
Instructor		**Type**	**SWS**
		Lecture	3

Course nr.	Course name		
16-98-4094-hü	Machine Dynamics		
Instructor		**Type**	**SWS**
		Lecture hall practice	1

<table>
<tr><td colspan="6">Module name
Machine Learning Applications</td></tr>
<tr><td>Module nr.
16-98-4174</td><td>Credit points
6 CP</td><td>Workload
180 h</td><td>Self-study
120 h</td><td>Module duration
1 Term</td><td>Module cycle
Every 2. Semester</td></tr>
<tr><td colspan="3">Language
English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Uwe Klingauf</td></tr>
</table>

1	**Teaching content** Theory: Application-oriented basics of machine learning and related areas statistics (descriptive, explorative, inductive), advanced analytics, data mining, data science and big data; basics of machine learning methods, functions and algorithms; development processes; basics of data science principles and techniques: discussion of business scenarios; collection, review and quality evaluation of data; data preparation, feature engineering; application of methods and use of program systems on the basis of examples; identification and evaluation of possible solutions; model selection, optimization, performance-assessment; essential ideas of model integration in decision-making processes, recommendations for actions, system of systems; examples from current research, e.g. predictive maintenance in aviation and production;Practical group work: Application of basic features of a software development methodology (e.g. scrum); application of theoretical knowledge on a cooperative development task; practical solution development of an industrial challenge through programming and data evaluation (implementation); documentation and presentation of the results.
2	**Learning objectives** On successful completion of this module, students should be able to: 1. Assess and evaluate basic developments and possible uses of artificial intelligence (machine learning) in engineering applications (e. g. mechanical engineering). 2. Differentiate and explain key concepts and (mathematical) methods of machine learning 3. Evaluate selected algorithms and models (e.g. from the diagnostic/prognostic domain) with regard to their performance, robustness and quality from an engineering point of view. 4. Apply learned competencies in the areas of data acquisition and processing, data-based modelling (diagnosis and prognosis) and prescription. 5. Structure simple and medium analytical tasks independently by means of standardized processes (CRISP/OSA-CBM), realize them with given data and estimate their economic impact (business value).
3	**Recommended prerequisites for participation** Programming knowledge in Matlab and/or Python is required.
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 60 Min., Default RS) Course related exam: • [16-98-4174-pr] (Technical examination, Special form, Default RS) 50 % written exam (60 min.) and special form: 50 % documentation, program code and oral exam (presentation of results, 15 min) of a cooperative development task („Data Quest“). Grading system: Technical Examinations (both 50%); Standard (Number grades).
5	**Prerequisite for the award of credit points** Passing both examinations
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 50 %) Course related exam: • [16-98-4174-pr] (Technical examination, Special form, Weighting: 50 %)
7	**Usability of the module** Master MB Ib Digitalisierung WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)

8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture material via moodle. Ertel: Grundkurs künstliche Intelligenz, Springer Mitchell: Machine Learning, McGraw Hill Hastie: The Elements of Statistical Learning, Springer Witten: Data Mining, Elsevier

Courses

Course nr.	Course name	Instructor	Type	SWS
16-98-4174-vl	Machine Learning Applications		Lecture	3
16-98-4174-pr	Machine Learning Applications (Group Work)		Lab	1

Module name Tools and Methods in Product Development					
Module nr. 16-05-5080	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Eckhard Kirchner		

1	**Teaching content** Basics of product development and structuring of the development process. Clarification of the task and requirement list, basics of development of new products, basics of management of product costs by reducing of manufacturing costs, value analysis and targeted costing; Development of environmentally safe products, development of products and product structures designed for variety; Basics of safety technology and development of products designed for safety; Failure and weak-point analysis; Utilizing Prototypes; Development and Production in a globalized world.
2	**Learning objectives** On successful completion of this module, students should be able to: 1. Analyse design tasks by questioning them specifically to identify targets and central issues of the design task. The students are also able to translate customer's wishes into product requirements and assess the requirement's importance. 2. Create a formal description of the design task by generating a list of requirements. The students are also able to differentiate between customer's wishes and requirements. 3. Describe principles, advantages, and limits of simultaneous engineering and explain its relevance and impact for practical work. 4. Denominate and describe the approach and the tasks of developing a new product, using a morphological analysis and systematic combination of solutions, as well as being able to explain their relevance in innovation projects. 5. Explain the principles of Total Quality Management and their implementation and relevance in companies. The students are also able to use FMEA as a preventive failure avoidance method. 6. Differentiate the basic wording for development of products designed to security and explain the principles of design to security regarding their effectiveness for specific tasks and use them to develop improved products. 7. Differentiate the main strategies of product cost management and knowing the basics of their genesis over the product's lifecycle. The students should also be able to analyse cost structures using breakeven-analysis, function costing and draft strategies and actions to reach the target costs and evaluate those strategies in regard to their reach. 8. Explain the approach and tasks of creating an ecobalance. 9. Analyse companies' situations regarding the variety of products and identify and explain the danger that comes from complexity. 10. Explain and evaluate limits of applicability of prototypes. 11. List the challenges of development and production in globally acting enterprises and to identify alleviating measures.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Default RS) Written exam (90 min) or oral exam (30 min). Will be announced at the beginning of the term depending on the circumstances (number of students, pandemic etc.).
5	**Prerequisite for the award of credit points** Passing the examination

6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** WP Bachelor MB
8	**Grade bonus compliant to §25 (2)**
9	**References** U. Lindemann. Methodische Entwicklung technischer Produkte: Methoden flexibel und situationsgerecht anwenden. VDI-Buch. Springer-Verlag Berlin Heidelberg, 2009. G. Pahl;W. Beitz; J. Feldhusen; K.H. Grote. Konstruktionslehre - Grundlagen erfolgreicher Produktentwicklung, Methoden und Anwendungen. Springer Verlag, Berlin, 2006. E. Kirchner & H. Birkhofer. Werkzeuge und Methoden der Produktentwicklung, Vorlesungsunterlagen des pmd, 2018

Courses

Course nr.	Course name	Instructor	Type	SWS
16-05-5080-vl	Tools and Methods in Product Development		Lecture	2
16-05-5080-ue	Tools and Methods in Product Development		Practice	2

3 Interdisciplinary modules of FB 18

Module name Standardization, Testing and Approvals in the Electrotechnical Area					
Module nr. 18-gt-4010	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1 Teaching content

In the European Union (EU), the fundamental requirements for lectrical equipment, such as safety and electromagnetical compatibility (EMC) including functionality, are stipulated in EC Directives and by national implementation in laws and decrees.
These requirements take shape in harmonized standards. The manufacturer or his authorized agent resident in the EU or, as the case may be, the user of the equipment has to show compliance with the requirements by means of

- Own tests **or**
- Tests carried out by an independent neutral testing laboratory.

During the lecture, these criteria are considered with respect to the following topics:

- Product safety law (ProdSG)
- Energy promotion law (EnWG)
- Law on electromagnetical compatibility of equipment (EMVG)
- Telecommunications law (TKG)
- Explosion-protection decree
- VDE Association for Electrical, Electronic and Information Technologies e.V. and DKE German Commission for Electrical, Electronic & Information Technologies in DIN and VDE
- Standardization:
  - On national level by DIN and DKE
  - In Europe by CENELEC (= European Committee of Electrotechnical Standardization)
  - Worldwide by IEC (= International Electrotechnical Commission).
- Application of regulation on the basis of case studies:
  - Case study 1: Functional Safety
  - Case Study 2: Protection against electric shock
  - Case Study 3: Information security

2 Learning objectives

After completing the module students are aware of connections between basic requirements given by law and technical standards for research adn development of electrotechnical equipment. As an outcome the participants will know the basic requirements for safety and reliability of such products.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS)

5 Prerequisite for the award of credit points

	Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** M.Sc. ESE
8	**Grade bonus compliant to §25 (2)**
9	**References** • Barz, N., Moritz, D.: EG - Niederspannungsrichtlinie Berlin/Offenbach: vde-verlag, 2008, 230 S. (VDE-Schriftenreihe Band 69) • Link für EG-Richtlinien: eur-lex.europa.eu/de/index.htm • Moritz, D.: Das Geräte- und Produktsicherheitsgesetz (GPSG) Berlin/Offenbach: vde-verlag, 2004, 138 S. (VDE-Schriftenreihe Band 116)

Courses

Course nr.	Course name		
18-gt-4010-vl	Standardization, Testing and Approvals in the Electrotechnical Area		
Instructor		**Type**	**SWS**
Dr.-Ing. Stefan Heusinger		Lecture	2

Module name What is Behind All this?					
Module nr. 18-dg-3002	**Credit points** 2 CP	**Workload** 60 h	**Self-study** 30 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Teaching content**
2	**Learning objectives**
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Colloquium, p/np RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Colloquium, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
18-dg-3002-ko	What is behind all this?		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Herbert De Gersem		Colloquium	2

Module name What is Behind All this?					
Module nr. 18-dg-3003	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Teaching content**
2	**Learning objectives**
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Special form, Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Special form, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
18-dg-3002-ko	What is behind all this?		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Herbert De Gersem		Colloquium	2

Module name Patents - How to Protect Technical Inventions					
Module nr. 18-fi-3010	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr.-Ing. Rolf Findeisen		

1	**Teaching content** Within the scope of this lecture aspects of national and international patent law as well as aspects of the law on employee will be treated as follows: • German, European and international filing procedures and their legal prerequisites (formal and substantive patent law) • Enforcement of technical property rights • Infringement of technical property rights • Law on employee invention - rights and obligations of employees and employers
2	**Learning objectives** After completing the module, students will be able to deal with basic patent law issues and will have gained insight into patent law practice.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 5 students register, the examination generally will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit
8	**Grade bonus compliant to §25 (2)**
9	**References**

- German Patent Law „Patentgesetz (PatG)“ - www.gesetze-im-internet.de/patg/index.html
- German Utility Model Act „Gebrauchsmustergesetz (GbmG)“ - www.gesetze-im-internet.de/gebrmg/index.html
- German Law on Employee Invention „Arbeitnehmererfindergesetz (ArbEG)“ - www.gesetze-im-internet.de/arbnerfg/index.html
- European Patent Convention „Europäisches Patent Übereinkommen (EPÜ)“ - www.epo.org/law-practice/legal-texts/epc_de.html
- Patent Cooperation Treaty (PCT) - www.wipo.int/pct/en/texts/index.html
- Paris Convention for the Protection of Industrial Property „Pariser Verbandsübereinkunft (PVÜ)“ - www.wipo.int/treaties/en/ip/paris/

Students will find a compilation of the relevant legal texts in the following book:
Patent- und Musterrecht; Beck im dtv - ISBN 978-3-406-66154-9

Courses

Course nr.	**Course name**		
18-fi-3010-vl	Patents - How to protect technical inventions		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Findeisen, Dr. Ing. Sebastian Clever		Lecture	2

4 Modules for other departments

Module name					
Introduction into the numerical computation of electromagnetic fields					
Module nr. 18-sc-3010	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. rer. nat. Sebastian Schöps		

1	**Teaching content** Maxwell´s equations, basics of numerical calculation of electromagnetic fields, knowledge about different types of possible errors
2	**Learning objectives** Starting from basic electromagnetic problems in terms of electric and magnetic circuits the field aspect inherent to these models is discussed. After attending the lecture, the student is capable of modeling given geometric structures and devices using the methods of Computational Engineering. Furthermore, the student is able to solve the related task numerically using appropriate software. The student should understand the basics of the numerical calculation of electromagnetic fields as well as become acquainted with the related procedures in practical applications. The gathered solution methods will be applied practically during the laboratory courses. Moreover basic programming skills related to specific simulation tasks as well as for the purpose of postprocessing the results of the numerical simulations are taught.
3	**Recommended prerequisites for participation** Elektrotechnik und Informationstechnik I und II
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 30 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be announced in the beginning of the lecture.
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. etit, B.Sc. CE, B.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)** yes
9	**References** Will be handed out during the lecture and is provided via Moodle
Courses	

	Course nr.	Course name		
	18-sc-3010-vl	Introduction into the numerical computation of electromagnetic fields		
	Instructor		**Type**	**SWS**
	M.Sc. Melina Merkel, Prof. Dr. rer. nat. Sebastian Schöps		Lecture	2
	Course nr.	**Course name**		
	18-sc-3010-ue	Introduction into the numerical computation of electromagnetic fields		
	Instructor		**Type**	**SWS**
	M.Sc. Melina Merkel, Prof. Dr. rer. nat. Sebastian Schöps		Project seminar	3

Module name Introduction to Electrical Engineering					
Module nr. 18-kn-3010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Teaching content** Basic physical quantities, fundamental forces, stationary charges - electrostatics, Coulomb's law, superposition, electrical field, electric flow, Gauss' law, area charge density, electrical potential and difference of potential, capacitor and term capacity, charging process, polarization, moving charge - electric flux field, drift velocity, electrical current, Ohm's law, elektrical power, voltage- and current source, battery, power matching, efficiency ratio, Kirchhoff law, linear DC circuits, term magnetism, magentic field, magnetic flux, electromagnet, electrodynamic principle - Lorentzforce, electric motor, solenoid and term inductance, Biot-Savart and Ampere's law, magentization, magnetic excitation and magnetic flux density, matter in magnetic field and explanation of hesterysis curve, Lenz's law, Faraday's law, generator principle, harmonic functions, basics alternating current quantities, pointer diagrams, basic elements and power in alternating current circuits, term of impedance, transient events in RC- and RL-elements, ODE of first order, complex variable domain, transformer, three-phase current, resonant circuits and mechanical analogy, two and four-port elements, measurement amplifiers, electrical lines and electromagnetic wave.
2	**Learning objectives** On successful completion of this module, students should be able to: • comprehend and analyze electric and magnetic fields, as well as the electric flux field, • utilize Maxwell's equations in integral form for this, • calculate currents and voltages in DC and AC circuits, • use complex numbers for electrical engineering, • calculate transient switching events, • comprehend and know the underlying principles of electrical machines (motor, generator, transformer), • comprehend the basics of resonant circuits, measurement amplifiers and closed loop systems, • know the mechanism behind energy- and information transfer via electric lines and electromagnetic waves.
3	**Recommended prerequisites for participation** Recommended: Mathematics I
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 150 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. Bio-Materials Engineering
8	**Grade bonus compliant to §25 (2)**
9	**References**

Lecture notes

- Vorlesungsfolien mit Abbildungen zum Download und Mitschreiben in Vorlesung über Lehrplattform,
- Aufzeichnungen (Bild und Ton) von Visualizer über Lehrplattform nach jeder Vorlesung,
- Vorlesungsfolien mit handschriftlichen Ergänzungen und Skizzen des Dozenten zum Download über Lehrplattform nach jeweiliger Vorlesung,
- Giancoli, Douglas C.: Physik Lehr- und Übungsbuch, Kapitel 21-32., 3. erweiterte Auflage, Pearson Studium Verlag, 2010 (Primärliteratur, relevanter Auszug < 15% nach UrhG Par 60a Abs. 1 vom 01.03.2018 wird zum Download über Lehrplattform nur für eingeschriebene Studierende bereitgestellt).
- Purcell, Edward M.: Elektrizität und Magnetismus, 4. Auflage, Vieweg Verlag, 1989 (vertiefend).
- Bergmann, Schaefer.: Lehrbuch der Experimentalphysik - Elektromagnetismus, Band 2, 9. Auflage, de Gruyter Verlag, 2006 (vertiefend)

Courses

Course nr.	Course name	Instructor	Type	SWS
18-kn-3010-vl	Introduction to Electrical Engineering	Prof. Dr. Mario Kupnik	Lecture	4
18-kn-3010-ue	Introduction to Electrical Engineering	Prof. Dr. Mario Kupnik, M.Sc. Felix Herbst, M.Sc. Sonja Wismath	Practice	2

Module name Introduction to Electrical Engineering					
Module nr. 18-kn-3011	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Teaching content** Basic physical quantities, fundamental forces, stationary charges - electrostatics, Coulomb's law, superposition, electrical field, electric flow, Gauss' law, area charge density, electrical potential and difference of potential, capacitor and term capacity, charging process, polarization, moving charge - electric flux field, drift velocity, electrical current, Ohm's law, elektrical power, voltage- and current source, battery, power matching, efficiency ratio, Kirchhoff law, linear DC circuits, term magnetism, magentic field, magnetic flux, electromagnet, electrodynamic principle - Lorentzforce, electric motor, solenoid and term inductance, Biot-Savart and Ampere's law, magentization, magnetic excitation and magnetic flux density, matter in magnetic field and explanation of hesterysis curve, Lenz's law, Faraday's law, generator principle, harmonic functions, basics alternating current quantities, pointer diagrams, basic elements and power in alternating current circuits, term of impedance, transient events in RC- and RL-elements, ODE of first order, complex variable domain, transformer, three-phase current, resonant circuits and mechanical analogy, two and four-port elements, measurement amplifiers, electrical lines and electromagnetic wave.
2	**Learning objectives** On successful completion of this module, students should be able to: • comprehend and analyze electric and magnetic fields, as well as the electric flux field, • utilize Maxwell's equations in integral form for this, • calculate currents and voltages in DC and AC circuits, • use complex numbers for electrical engineering, • calculate transient switching events, • comprehend and know the underlying principles of electrical machines (motor, generator, transformer), • comprehend the basics of resonant circuits, measurement amplifiers and closed loop systems, • know the mechanism behind energy- and information transfer via electric lines and electromagnetic waves.
3	**Recommended prerequisites for participation** Recommended: Mathematics I
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 150 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. Materialwissenschaften
8	**Grade bonus compliant to §25 (2)**
9	**References**

Lecture notes

- Vorlesungsfolien mit Abbildungen zum Download und Mitschreiben in Vorlesung über Lehrplattform,
- Aufzeichnungen (Bild und Ton) von Visualizer über Lehrplattform nach jeder Vorlesung,
- Vorlesungsfolien mit handschriftlichen Ergänzungen und Skizzen des Dozenten zum Download über Lehrplattform nach jeweiliger Vorlesung,
- Giancoli, Douglas C.: Physik Lehr- und Übungsbuch, Kapitel 21-32., 3. erweiterte Auflage, Pearson Studium Verlag, 2010 (Primärliteratur, relevanter Auszug < 15% nach UrhG Par 60a Abs. 1 vom 01.03.2018 wird zum Download über Lehrplattform nur für eingeschriebene Studierende bereitgestellt).
- Purcell, Edward M.: Elektrizität und Magnetismus, 4. Auflage, Vieweg Verlag, 1989 (vertiefend).
- Bergmann, Schaefer.: Lehrbuch der Experimentalphysik - Elektromagnetismus, Band 2, 9. Auflage, de Gruyter Verlag, 2006 (vertiefend)

Courses

	Course nr. 18-kn-3010-vl	**Course name** Introduction to Electrical Engineering		
	Instructor Prof. Dr. Mario Kupnik		**Type** Lecture	**SWS** 4
	Course nr. 18-kn-3010-ue	**Course name** Introduction to Electrical Engineering		
	Instructor Prof. Dr. Mario Kupnik, M.Sc. Felix Herbst, M.Sc. Sonja Wismath		**Type** Practice	**SWS** 2

Module name Introduction to Electrical Engineering for BEd					
Module nr. 18-kn-3012	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 0 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Teaching content** Basic physical quantities, fundamental forces, stationary charges - electrostatics, Coulomb's law, superposition, electrical field, electric flow, Gauss' law, area charge density, electrical potential and difference of potential, capacitor and term capacity, charging process, polarization, moving charge - electric flux field, drift velocity, electrical current, Ohm's law, elektrical power, voltage- and current source, battery, power matching, efficiency ratio, Kirchhoff law, linear DC circuits, term magnetism, magentic field, magnetic flux, electromagnet, electrodynamic principle - Lorentzforce, electric motor, solenoid and term inductance, Biot-Savart and Ampere's law, magentization, magnetic excitation and magnetic flux density, matter in magnetic field and explanation of hesterysis curve, Lenz's law, Faraday's law, generator principle, harmonic functions, basics alternating current quantities, pointer diagrams, basic elements and power in alternating current circuits, term of impedance, transient events in RC- and RL-elements, ODE of first order, complex variable domain, transformer, three-phase current, resonant circuits and mechanical analogy, two and four-port elements, measurement amplifiers, electrical lines and electromagnetic wave.
2	**Learning objectives** On successful completion of this module, students should be able to: • comprehend and analyze electric and magnetic fields, as well as the electric flux field, • utilize Maxwell's equations in integral form for this, • calculate currents and voltages in DC and AC circuits, • use complex numbers for electrical engineering, • calculate transient switching events, • comprehend and know the underlying principles of electrical machines (motor, generator, transformer), • comprehend the basics of resonant circuits, measurement amplifiers and closed loop systems, • know the mechanism behind energy- and information transfer via electric lines and electromagnetic waves.
3	**Recommended prerequisites for participation** Recommended: Mathematics I
4	**Form of examination** Module exam: • Module exam (Technical examination, Examination, Duration: 150 Min., Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References**

Lecture notes

- Vorlesungsfolien mit Abbildungen zum Download und Mitschreiben in Vorlesung über Lehrplattform,
- Aufzeichnungen (Bild und Ton) von Visualizer über Lehrplattform nach jeder Vorlesung,
- Vorlesungsfolien mit handschriftlichen Ergänzungen und Skizzen des Dozenten zum Download über Lehrplattform nach jeweiliger Vorlesung,
- Giancoli, Douglas C.: Physik Lehr- und Übungsbuch, Kapitel 21-32., 3. erweiterte Auflage, Pearson Studium Verlag, 2010 (Primärliteratur, relevanter Auszug < 15% nach UrhG Par 60a Abs. 1 vom 01.03.2018 wird zum Download über Lehrplattform nur für eingeschriebene Studierende bereitgestellt).
- Purcell, Edward M.: Elektrizität und Magnetismus, 4. Auflage, Vieweg Verlag, 1989 (vertiefend).
- Bergmann, Schaefer.: Lehrbuch der Experimentalphysik - Elektromagnetismus, Band 2, 9. Auflage, de Gruyter Verlag, 2006 (vertiefend)

Courses

Course nr.	Course name	Instructor	Type	SWS
18-kn-3010-vl	Introduction to Electrical Engineering	Prof. Dr. Mario Kupnik	Lecture	4
18-kn-3010-ue	Introduction to Electrical Engineering	Prof. Dr. Mario Kupnik, M.Sc. Felix Herbst, M.Sc. Sonja Wismath	Practice	2

<table>
<tr><td colspan="6">Module name
Applied Computational Modeling and Analysis</td></tr>
<tr><td>Module nr.
18-kp-3020</td><td>Credit points
6 CP</td><td>Workload
180 h</td><td>Self-study
90 h</td><td>Module duration
1 Term</td><td>Module cycle
Winter term</td></tr>
<tr><td colspan="3">Language
English</td><td colspan="3">Module owner
Prof. Dr. techn. Heinz Köppl</td></tr>
</table>

1	**Teaching content** The module provides an introduction to modeling and analysis approaches relevant to synthetic biology. It builds on the mathematical basis provided in the module “mathematical foundations of modeling and analysis”. Apart from short introductory lectures, practical programming of respective algorithms will be the main modality to learn the subject. The course covers purely data-driven methods from biostatistics and machine learning but also first-principle modeling approaches from biophysics and biochemistry. Concrete scientific problem statements will used to learn about the modeling and analysis algorithms. • Introduction to scientific programming using Julia • Introduction to biostatistics, bioinformatics and machine learning • Deterministic and stochastic approaches for modeling reaction networks • Thermodynamic analysis of reactions networks • Principles of molecular dynamics, structure prediction • Statistical methods for structure prediction • Numerical solution and simulation methods
2	**Learning objectives** Students gained an overview of relevant computational approaches in the area of synthetic biology. They can categorize approaches and find dedicated literature for an in-depth coverage. They are able to understand new modeling and analysis algorithms and are able to implement them on their own in a programming language of choice. They know how to practically handle real experimental data, analyze the data and utilize data with a modeling project. They are able to work in a team efficiently to make progress on a scientific problem.
3	**Recommended prerequisites for participation** Passing of module “Basics in Synthetic Biology”
4	**Form of examination** Module exam: • Module exam (Technical examination, Presentation, Default RS)
5	**Prerequisite for the award of credit points** Passing the exams. Compulsory attendance in 75% of the seminar. A focus of the module is on making progress on a scientific problem in a team. For this purpose, it is necessary that the team members spend time together as a team.
6	**Grading** Module exam: • Module exam (Technical examination, Presentation, Weighting: 100 %)
7	**Usability of the module** M.Sc. Synthetic Biology
8	**Grade bonus compliant to §25 (2)**
9	**References**

- Neil Jones & Pavel Pevzner. An Introduction to bioinformatics algorithms, MIT Press, 2004
- Daniel Beard & Hing Qian. Chemical Biophysics, Cambridge University Press, 2010
- Darren Wilkinson. Stochastic modeling for systems biology, CRC Press, 2006
- Kevin P. Murphy. Machine Learning - A probabilistic perspective, MIT Press, 2012

Courses

Course nr.	Course name		
18-kp-3020-vl	Applied computational modeling and analysis		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Heinz Köppl		Lecture	1
Course nr.	**Course name**		
18-kp-3020-se	Applied computational modeling and analysis		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Heinz Köppl		Seminar	5

Module name Fundamentals of Electrical Engineering and Power Systems					
Module nr. 18-st-3020	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1 Teaching content

- Direct current circuits: Ohm's law, Kirchhoff's theorems
- Alternating current circuits: dynamic behavior of coils and capacitors, computation via phasors and complex-valued impedances, active and reactive power
- Electro-magnetic fields: source and vortex fields, Coulomb's law, electrical displacement density, influence, magnetic fields, induction, Maxwell's laws in integral form
- Elements of power engineering: three phase systems, transformators, electrical machines, power electronics and power converters
- Introduction into current research topics in power engineering

2 Learning objectives

After the course, students are able to name the electric variables and components, to calculate the electric direct- and alternating current circuits, and to derive electric and magnetic fields in simple, quasi-stationary settings. Moreover, they know the working principles of important power system components.

3 Recommended prerequisites for participation

Basic mathematics: working with complex numbers, matrices / vectors / systems of linear equations, ordinary differential equations

4 Form of examination

Module exam:

- Module exam (Technical examination, Oral/written examination, Duration: 120 Min., Default RS)

The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 7 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be announced in the beginning of the lecture.

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

M.Sc. ESE, M.Sc. CE, B.Sc. CE

8 Grade bonus compliant to §25 (2)

9 References

A lecture script and slides are provided via Moodle.

Courses

Course nr.	**Course name**		
18-st-3020-vl	Fundamentals of Electrical Engineering and Power Systems		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Florian Steinke, M.Sc. Adeel Jamal, M.Sc. Sara Mollaeivaneghi, Prof. Dr.-Ing. Gerd Griepentrog		Lecture	3

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-st-3020-ue</td><td colspan="3">Course name
Fundamentals of Electrical Engineering and Power Systems</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. rer. nat. Florian Steinke, M.Sc. Adeel Jamal, M.Sc. Sara Mollaeivaneghi, Prof. Dr.-Ing. Gerd Griepentrog</td><td>Type
Practice</td><td>SWS
1</td></tr>
</table>

5 Final Modules

Module name Bachelorthesis					
Module nr. 18-00-4000	**Credit points** 12 CP	**Workload** 360 h	**Self-study** 360 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner**		

1 Teaching content

Students independently prepare a written paper on a scientific question, taking into account relevant scientific articles and specialist literature. The Bachelor thesis is written in a limited amount of time and takes into account the principles of scientific work. Further general conditions are specified by the offering department when the task is assigned.

2 Learning objectives

After completion of the module, students are able to,

- work independently on a scientific problem according to scientific principles.
- apply the knowledge, methods and competences acquired in the Bachelor's program.
- to research, narrow down and evaluate the relevant literature.
- to systematize the topic in a meaningful way and to build up a line of argument.
- weigh the validity of pro and contra arguments in a comprehensible way.
- to set down the results in writing according to scientific criteria.
- represent the results in an argumentative manner.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

- Module exam (Technical examination, Written examination, Default RS)
- Module exam (Technical examination, Colloquium, Duration: 30 Min., Default RS)

Final examination consisting of the preparation of a thesis

5 Prerequisite for the award of credit points

Passing the final module examination

6 Grading

Module exam:

- Module exam (Technical examination, Written examination, Weighting: 80 %)
- Module exam (Technical examination, Colloquium, Weighting: 20 %)

7 Usability of the module

B.Sc. etit, B.Sc. MEC, B.Sc. MedTec, B.Sc. iST

8 Grade bonus compliant to §25 (2)

9 References

	Topic-dependent research literature as introductory reading in German and English, which can be supplemented independently in a meaningful way.
Courses	

Module name Masterthesis					
Module nr. 18-00-5000	**Credit points** 30 CP	**Workload** 900 h	**Self-study** 900 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner**		

1	**Teaching content** Students independently prepare a written paper on a scientific question, taking into account relevant scientific articles and specialist literature. The Bachelor thesis is written in a limited amount of time and takes into account the principles of scientific work. Further general conditions are specified by the offering department when the task is assigned.
2	**Learning objectives** After completion of the module, students are able to, • work independently on a scientific problem according to scientific principles. • apply the knowledge, methods and competences acquired in the Master's program. • to research, narrow down and evaluate the relevant literature. • to systematize the topic in a meaningful way and to build up a line of argument. • weigh the validity of pro and contra arguments in a comprehensible way. • to set down the results in writing according to scientific criteria. • represent the results in an argumentative manner.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Colloquium, Duration: 30 Min., Default RS) • Module exam (Technical examination, Written examination, Default RS) Final examination consisting of the preparation of a thesis
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Colloquium, Weighting: 20 %) • Module exam (Technical examination, Written examination, Weighting: 80 %)
7	**Usability of the module** M.Sc. etit, M.Sc. MEC, M.Sc. MedTec, M.Sc. iST
8	**Grade bonus compliant to §25 (2)**
9	**References** Topic-dependent research literature as introductory reading in German and English, which can be supplemented independently in a meaningful way.
Courses	

Module name Masterthesis iCE					
Module nr. 18-20-5000	**Credit points** 30 CP	**Workload** 900 h	**Self-study** 900 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language English			**Module owner**		

1	**Teaching content** Students independently prepare a written paper on a scientific question, taking into account relevant scientific articles and specialist literature. The Bachelor thesis is written in a limited amount of time and takes into account the principles of scientific work. Further general conditions are specified by the offering department when the task is assigned.
2	**Learning objectives** After completion of the module, students are able to, • work independently on a scientific problem according to scientific principles. • apply the knowledge, methods and competences acquired in the Master's program. • to research, narrow down and evaluate the relevant literature. • to systematize the topic in a meaningful way and to build up a line of argument. • weigh the validity of pro and contra arguments in a comprehensible way. • to set down the results in writing according to scientific criteria. • represent the results in an argumentative manner.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Colloquium, Duration: 30 Min., Default RS) • Module exam (Technical examination, Written examination, Default RS) Final examination consisting of the preparation of a thesis
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Colloquium, Weighting: 20 %) • Module exam (Technical examination, Written examination, Weighting: 80 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References** Topic-dependent research literature as introductory reading in German and English, which can be supplemented independently in a meaningful way.
Courses	

Module name Masterthesis ESE					
Module nr. 18-70-5010	**Credit points** 30 CP	**Workload** 900 h	**Self-study** 900 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Gerd Griepentrog		

1	**Teaching content** Students independently prepare a written paper on a scientific question, taking into account relevant scientific articles and specialist literature. The Master thesis is written in a limited amount of time and takes into account the principles of scientific work. Further general conditions are specified by the offering department when the task is assigned.
2	**Learning objectives** After completion of the module, students are able to, • work independently on a scientific problem according to scientific principles. • apply the knowledge, methods and competences acquired in the Master's program. • to research, narrow down and evaluate the relevant literature. • to systematize the topic in a meaningful way and to build up a line of argument. • weigh the validity of pro and contra arguments in a comprehensible way. • to set down the results in writing according to scientific criteria. • represent the results in an argumentative manner.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Colloquium, Duration: 30 Min., Default RS) • Module exam (Technical examination, Written examination, Default RS) Final examination consisting of the preparation of a thesis
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Colloquium, Weighting: 20 %) • Module exam (Technical examination, Written examination, Weighting: 80 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References** Topic-dependent research literature as introductory reading in German and English, which can be supplemented independently in a meaningful way.
Courses	