Options B.Sc. / M.Sc. Information System Technology (PO 2023)

Module handbook
FB 18
Date: 01.09.2023

TECHNISCHE UNIVERSITÄT DARMSTADT

FB 18

Module handbook: Options B.Sc. / M.Sc. Information System Technology (PO 2023)

Date: 01.09.2023

FB 18
Email: servicezentrum@etit.tu-darmstadt.de

Contents

1 Options

1.1 Optional Subjects CTS: Communication Technology and Communication Systems

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** BSc ETiT, BSc MEC
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

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
BSc ETiT, 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 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** BSc ETiT, BSc iST, MSc iCE, BSc Wi-ETiT, BSc/MSc CE
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 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** BSc ETiT, BSc Wi-ETiT, BSc CE, BSc iST, BSc MEC
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					
Advanced Seminar on Networking, Security, Mobility, and Wireless Communications					
Module nr. 20-00-0549	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Karsten Weihe		

1 Teaching content

The Advanced Seminar on Networking, Security, Mobility, and Wireless Communications covers current research that is considered highly relevant for the future development of the given topic areas. Goal of the seminar is to explore the aforementioned research area by studying, critically analyzing and discussing, summarizing, and presenting selected first-rate research articles. Deliverables are a short presentation, a final presentation, and a seminar paper.

The prospective topics for the advanced seminar will be derived from the current research topics of the SEEMOO group.

Course contents:
- Indepentent exploration of a topic in the area of networking, security, mobility, and wireless communications (typically in english)
- Own, enhanced literature study
- Interpretation and classification of the literature study
- Preparation of an introductory talk as well as a final talk including presentation slides
- Presentation of both talks for a heterogenous audience (experts/non-experts)
- Technical discussion after the talks
- Feedback to the speakers and the talks (including presentation skills) and technical content
- Understanding the process of scientific work as well as of scientific publications

2 Learning objectives

After successfully attending the course, students are able to independently explore new topics in a scientific manner. They have aquired detailed knowledge on selected mechanisms, methodologies as well as applications for the investigated topic area. Techniques such as thoroughly surveying literature, critical discussion and analysis of scientific articles, and the presentation of the obtained results are demonstrated by the students. Students can defend their work against a critical technical audience.

3 Recommended prerequisites for participation

Successfull participation of an lecture of SEEMOO

4 Form of examination

Course related exam:
- [20-00-0549-se] (Study achievement, Oral/written examination, Default RS)

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:
- [20-00-0549-se] (Study achievement, 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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be announced in seminar.
Courses	

	Course nr. 20-00-0549-se	**Course name** Advanced Seminar on Networking, Security, Mobility, and Wireless Communications		
	Instructor Prof. Dr.-Ing. Matthias Hollick		**Type** Seminar	**SWS** 3

Module name					
Wireless Network for Emergency Response: Fundamentals, Design, and Build-up from Scratch					
Module nr. 20-00-0780	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. rer. nat. Eberhard Mühlhäuser		

1	**Teaching content** The communication capabilities among the population is of utmost importance to respond to crises. This course will discuss how to build wireless communication systems from scratch, i.e. under the assumption that no communication infrastructure is left intact as a result of the crisis. The course introduces the theoretical basis from the fields of amateur radio as well as communication systems. It deepens these fields with the knowledge to design and build communication networks for times of crisis. The discussed technologies will span from local to global wireless communications without need of further infrastructure. Theoretical exercises as well as experimentation, the design and building of electrical circuits and the analysis of wireless technology under laboratory conditions deepen the understanding of the subject. Course contents: - Signals, signal propagation, antennas, basics of electrical engineering - Modulation schemes in analog and digital systems (OFDM, ATV/SSTV, Packet Radio, SSB, ...) - System aspects for communication in times of crisis - Design and practical realization from scratch of wireless communication systems
2	**Learning objectives** After successfully attending the course, students have theoretical and practical knowledge in the area of wireless and infrastructureless communication for emergency response. They understand the most important physical and electrotechnical basics of wireless communications and know wireless transmission mechanisms in theory and practice. They are able to build a wireless communication system from scratch and operate it. The students acquire competences in the area of amateur radio and software defined radio technology.
3	**Recommended prerequisites for participation**
4	**Form of examination** Course related exam: • [20-00-0780-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0780-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 Can 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** Selected and given in lecture.

Courses

Course nr.	Course name		
20-00-0780-iv	Wireless Network for Emergency Response: Fundamentals, Design, and Build-up from Scratch		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Eberhard Mühlhäuser		Integrated course	3

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.-Ing. Ralf Steinmetz		

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** Wi-CS, Wi-ETiT, BSc CS, BSc ETiT, BSc iST
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	Instructor	Type	SWS
18-sm-1010-vl	Communication Networks I	Prof. Dr.-Ing. Ralf Steinmetz	Lecture	3
18-sm-1010-ue	Communication Networks I	Prof. Dr.-Ing. Ralf Steinmetz	Practice	1

Module name Seminar Telecooperation					
Module nr. 20-00-0130	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. rer. nat. Eberhard Mühlhäuser		

1	**Teaching content** The TK Seminar is cycle of seminar where students are given the chance to read and analyze current scientific publications.
2	**Learning objectives** After participation in the seminar Telekooperation, students - have been introduced to the research area of their seminar topic - are able to critically read and analyze scientific papers - can document and present the evaluation of such critical analysis in both written and spoken form
3	**Recommended prerequisites for participation** General knowledge within Computer Science based on Bachelor.
4	**Form of examination** Course related exam: • [20-00-0130-se] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0130-se] (Study achievement, 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)**
9	**References** W. Strunk, E. B. White. The Elements of Style, Pearson, ISBN 0-321-24861-9

Courses

Course nr.	**Course name**		
20-00-0130-se	Seminar Telecooperation		
Instructor		**Type** Seminar	**SWS** 2

Module name TK1: Distributed Systems and Algorithms					
Module nr. 20-00-0065	**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. Eberhard Mühlhäuser		

1 Teaching content

Objectives:

- Comprehensive overview about the fundamental problems and approaches in distributed computing
- In-depth methodological knowledge of classical distributed algorithms and programming paradigms
- Applicable exemplary knowledge of current developments and standards

Syllabus:

- Introduction
- Refresher and supplement to Chapter 1 of the Net-Centric Computing canon.
- Overview of the lecture
- Distributed Algorithms
  - Elementary algorithms (e.g., global state).
  - Basic algorithms (e.g., exclusion, consensus, cooperation)
  - Formalization (properties and their proof).
- Distributed Programming
  - Push paradigms (e.g., IPC, RPC, DOC)
  - Current approaches (e.g., pull paradigms, object mobility)

2 Learning objectives

After successful completion of the module, students are familiar with the concepts of distributed algorithms and programming. They understand the fundamental issues of distributed systems and the classical distributed algorithms and programming paradigms. They are able to apply these classical and current standards of distributed programming to given problems.

3 Recommended prerequisites for participation

Recommended: Computer Networks and Distributed Systems

4 Form of examination

Course related exam:

- [20-00-0065-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:

- [20-00-0065-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

	B.Sc. Informatik M.Sc. Informatik M.Sc. Computer Science M.Sc. Autonome Systeme und Robotik M.Sc. IT Sicherheit M.Sc. IT Security 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** Literature recommendations will be updated regularly, an example might be: - George Coulouris, Jean Dollimore, Tim Kindberg: Distributed Systems. Concepts and Design (Gebundene Ausgabe) 832 Seiten, Addison Wesley; Auflage: 4th (14. Juni 2005), ISBN: 0321263545 - M. Boger: Java in verteilten Systemen, 1999, dpunkt-Verlag, Heidelberg, ISBN: 3932588320 - G. Tel: Introduction to Distributed Algorithms, 2nd Ed 2001, Cambridge University Press, ISBN: 0521794838 - A. Tanenbaum, M.v.Steen, Verteilte Systeme: Grundlagen und Paradigmen, Pearson Studium 2003, ISBN: 3827370574 - A. Tanenbaum: Computernetzwerke. 4te Auflage. Pearson Studium 2003, ISBN-10: 3827370469 - J. Kurose, K. Ross: Computer Networking, 1. Ed. 2000, Adison-Wesley. ISBN: 0201477114 - L. Peterson, B. Davie, Computernetze, 1. Aufl. 2000, dpunkt Heidelberg, ISBN: 393258869X - Hammerschall, U.: Verteilte Systeme und Anwendungen. Pearson, München 2005, ISBN: 3827370965

Courses

Course nr.	Course name		
20-00-0065-iv	TK1: Distributed Systems and Algorithms		
Instructor		**Type**	**SWS**
		Integrated course	4

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** BSc ETiT, BSc/MSc iST, MSc MEC, Wi-CS, Wi-ETiT, BSc/MSc CS
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.-Ing. Ralf Steinmetz, Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing. Julian Zobel, M.Sc. Fridolin Siegmund	Internship	3

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** BSc ETiT, BSc/MSc iST, MSc MEC, Wi-CS, Wi-ETiT, BSc/MSc CS
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.-Ing. Ralf Steinmetz, Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing. Julian Zobel, M.Sc. Fridolin Siegmund		Project seminar	4

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** BSc ETiT, Wi-ETiT, MSc Medizintechnik
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**
M.Sc. Martin Gölz, Prof. Dr.-Ing. Abdelhak Zoubir		Lecture	3

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

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** MSc ETIT, MSc Wi-ETiT, MSc CE, MSc iCE, MSc iST, MSc MEC
8	**Grade bonus compliant to §25 (2)**
9	**References**

	will be announced in the lecture			
Courses				
	Course nr. 18-kl-2020-vl	**Course name** Mobile Communications		
	Instructor Prof. Dr.-Ing. Anja Klein, Dr.-Ing. Lin Xiang		**Type** Lecture	**SWS** 3
	Course nr. 18-kl-2020-ue	**Course name** Mobile Communications		
	Instructor Prof. Dr.-Ing. Anja Klein, Dr.-Ing. Lin Xiang		**Type** Practice	**SWS** 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** MSc ETiT
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.	Course name		
	18-pe-2020-vl	Convex Optimization in Signal Processing and Communications		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Marius Pesavento		Lecture	2
	Course nr.	**Course name**		
	18-pe-2020-ue	Convex Optimization in Signal Processing and Communications		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Marius Pesavento		Practice	1
	Course nr.	**Course name**		
	18-pe-2020-pr	Convex Optimization in Signal Processing and Communications Lab		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Marius Pesavento		Internship	1

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

MSc ETiT

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 Seminar Smart City					
Module nr. 20-00-0619	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner**		

1	**Teaching content** Rapid urbanization presents cities with complex challenges, from socio-economic and environmental problems to issues involving infrastructure and governance. In the seminar students will have a look at different technical approaches to cope with these different challenges, e.g. for traffic prediction, analysis of environmental data or disaster preparation and management.
2	**Learning objectives** The students learn fundamentals of scientific work when interacting with existing Smart City literature. Furthermore, the students get a good overview of the topic smart city.
3	**Recommended prerequisites for participation**
4	**Form of examination** Course related exam: • [20-00-0619-se] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0619-se] (Study achievement, 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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References** Various

Courses

Course nr.	Course name		
20-00-0619-se	Seminar Smart City		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Eberhard Mühlhäuser		Seminar	2

Module name IoT and wireless protocols in embedded systems					
Module nr. 20-00-1064	**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. rer. nat. Eberhard Mühlhäuser		

1	**Teaching content** As part of the internship, students become acquainted with IoT and radio protocols and independently carry out a project with embedded hardware. In addition, aspects of IT security are also taken into account. The main focus is on Bluetooth LE, Bluetooth Mesh, LoRaWAN and communication via OOB channels. Depending on the selected project topic, hardware (microcontrollers, FPGAs, RF transceivers, software defined radio, etc.) as well as laboratory environment (logic analyzers, RF analyzers, oscilloscopes, etc.) are provided.
2	**Learning objectives** At the end of the course, students will be able to deal with complex specifications of radio protocols and transfer them into practice. Furthermore, the practical handling of embedded systems and laboratory equipment is taught.
3	**Recommended prerequisites for participation** Previous knowledge in computer networks (compulsory lecture "Computer Networks and Distributed Systems) and Embedded Systems (compulsory lectures Computer Organization and / or Data Engineering) Knowledge of the programming language C and basic knowledge of electrical engineering are helpful, as well as knowledge from relevant lectures in the field" Networks and Systems " Distributed systems "such as TK3, mobile networks or KN1.
4	**Form of examination** Course related exam: • [20-00-1064-pr] (Study achievement, Oral/written examination, Default RS) Pass exam (100%)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Course related exam: • [20-00-1064-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**

Courses

Course nr.	**Course name**		
20-00-1064-pr	IoT and wireless protocols in embedded systems		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Eberhard Mühlhäuser		Internship	4

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

MSc etit, MSc (WI-)etit, BSc/MSc iST

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					
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** MSc ETIT, MSc Wi-ETiT, MSc CE, MSc iCE, MSc iST, MSc MEC
8	**Grade bonus compliant to §25 (2)**
9	**References** will be announced in the lecture

Courses

	Course nr. 18-kl-2010-vl	**Course name** Communication Technology II		
	Instructor Prof. Dr.-Ing. Anja Klein		**Type** Lecture	**SWS** 2
	Course nr. 18-kl-2010-ue	**Course name** Communication Technology II		
	Instructor Prof. Dr.-Ing. Anja Klein		**Type** Practice	**SWS** 2

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

<table>
<tr><td colspan="6">Module name
Digital Signal Processing Lab</td></tr>
<tr><td>Module nr.
18-zo-2030</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
English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Abdelhak Zoubir</td></tr>
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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** MSc ETiT, MSc iCE
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		Internship	3

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** MSc ETiT, MSc iCE, BSc/MSc iST, Wi-ETiT, BSc/MSc CS, Wi-CS,
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.-Ing. Ralf Steinmetz, Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing. Julian Zobel, M.Sc. Fridolin Siegmund		Internship	3

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** Wi-CS, Wi-ETiT, BSc/MSc CS, MSc ETiT, MSc 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.-Ing. Ralf Steinmetz, Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing. Julian Zobel, M.Sc. Fridolin Siegmund	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** MSc ETiT, MSc Wi-ETiT, MSc CE, MSc iCE, MSc iST, MSc MEC
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**
M.Sc. Sumedh Dongare, Prof. Dr.-Ing. Anja Klein		Project seminar	4

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** CS, Wi-CS, ETiT, Wi-ETiT, MSc CS, MSc ETiT, MSc iST
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-2090-se	Multimedia Communications Seminar II		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Ralf Steinmetz, Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing. Julian Zobel, M.Sc. Fridolin Siegmund		Seminar	2

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

	MSc ETiT
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 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** MSc ETiT, BSc/MSc iST, MSc iCE, Wi-ETiT
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		Seminar	4

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** BSc ETiT, MSc ETiT, MSc iCE, 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. 18-jk-2020-vl	**Course name** Antennas and Adaptive Beamforming		
	Instructor Prof. Dr.-Ing. Rolf Jakoby, M.Sc. Matthias Nickel		**Type** Lecture	**SWS** 3
	Course nr. 18-jk-2020-ue	**Course name** Antennas and Adaptive Beamforming		
	Instructor Prof. Dr.-Ing. Rolf Jakoby, M.Sc. Matthias Nickel		**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

MSc ETiT, MSc iCE, MSc IST, Wi-ETiT

8 Grade bonus compliant to §25 (2)

9 References

Script and slides will be handed out. Literature will be recommended in the lecture.

Courses

	Course nr. 18-jk-2130-vl	**Course name** Microwave Engineering II		
	Instructor PD Dr.-Ing. Oktay Yilmazoglu		**Type** Lecture	**SWS** 3
	Course nr. 18-jk-2130-ue	**Course name** Microwave Engineering II		
	Instructor PD Dr.-Ing. Oktay Yilmazoglu		**Type** Practice	**SWS** 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** MSc Wi-ETiT, BSc/MSc CS, MSc Wi-CS, MSc ETiT, MSc 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.-Ing. Ralf Steinmetz, Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing. Julian Zobel, M.Sc. Fridolin Siegmund		Internship	6

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

BSc ETiT, BSc Wi-ETiT, BSc CE, BSc iST, BSc MEC

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					
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** BSc ETiT, BSc Wi-ETiT, BSc CE, BSc iST, BSc MEC
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**
Dr.-Ing. Martin Schüßler, Prof. Dr.-Ing. Rolf Jakoby		Project seminar	4

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** BSc ETiT, BSc Wi-ETiT, BSc CE, BSc iST, BSc MEC
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**
M.Sc. Sumedh Dongare, Prof. Dr.-Ing. Anja Klein		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** BSc ETiT, BSc Wi-ETiT, BSc CE, BSc iST, BSc MEC
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 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** MSc ETiT, MSc Wi-ETiT, MSc iCE
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. David Schenck		Project seminar	4

Module name					
Internet - Practical Course Telecooperation					
Module nr. 20-00-0131	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Eberhard Mühlhäuser		

1	**Teaching content** The Praktikum is divided into three parts. In each of the parts, there will be one lecture for reviewing the basic concepts in that part and for introducing new material. After the lecture, the students will have roughly 4 weeks to implement the assignment given in the lecture. Each of the assignments will be graded separately and all of the grades will be used to determine the total grade for the Praktikum. Relevant topics are: - Introduction to Java network programming and HTTP - Peer-to-peer technologies - Web caching - Internet standards
2	**Learning objectives** Students will have aquired knowledge on currently evolving technologies. Thus, students will have used these building blocks of future-generation Internet services practically and will have gathered experiences with using, developing and integrating those technologies.
3	**Recommended prerequisites for participation** Net Centric Systems
4	**Form of examination** Course related exam: • [20-00-0131-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0131-pr] (Study achievement, 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)**
9	**References** 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
Courses	

	Course nr.	Course name		
	20-00-0131-pr	Internet - Practical Course Telecooperation		
	Instructor		**Type**	**SWS**
			Internship	4

Module name					
Mobile Networking					
Module nr. 20-00-0748	**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. Thorsten Strufe		

1	**Teaching content** Mobile communications and wireless networking technology has seen a thriving development in recent years. The integrated course addresses the characteristics/principles of mobile networks in detail, and practical solutions are presented. Hereby our focus is on the network layer, which is often regarded as the glue of communication systems. In addition to describing the state of the art in technology we discuss actual research problems and learn about methodologies to approach such problems systematically. The contents of the course will be deepended by exercises. Course contents: - Introduction to mobile and wireless communications: Applications, history, market vision - Overview of wireless transmission: frequencies & regulations, signals, antennas, signal propagation, multiplexing, modulation, spread spectrum, cellular systems - Medium access control in the wireless domain: SDMA, FDMA, CDMA TDMA (fixed, Aloha, CSMA, DAMA, PRMA, MACA, collision avoidance, polling) - Wireless local area networks: IEEE 802.11 standard including physical layer, MAC layer and access schemes, quality of service and power management - Wireless metropolitan area networks: Wireless mesh networks, IEEE 802.16 standard including modes of operation, medium access control, quality of service and scheduling - Mobility at network layer: Concepts to support mobility on various layers, Mobile IP - Ad hoc networks: Terminology, basics and applications, characteristics of ad hoc communication, ad hoc routing paradigms and protocols - Performance evaluation of mobile networks: Overview of performance evaluation, systematic approach / common mistakes and how to avoid them, experimental design and analysis - Mobility at transport layer: Variants of TCP (indirect TCP, snoop TCP, mobile TCP, wireless TCP) - Mobility at application layer. Outlook: Applications for mobile networks and wireless sensor networks
2	**Learning objectives** After successfully attending the course, students have an in-deep knowledge on the working of mobile communication networks. They have gained insight into media access control mechanisms dedicated to wireless communication and have a thorough understanding of mechanisms based on the network and the transport layers, with a focus on ad hoc and mesh networks. Moreover, the students have acquired knowledge about the connections between the different protocol layers and are able to apply the acquired knowledge on methodological analysis of real communication systems. The students are therefore be conversant with the characteristics and basic principles of wireless and mobile communications in theory and practice. The exercise-parts of the integrated course deepen the theoretical foundations by means of exercises, which consist of literature, calculation as well as practical implementation/application examples.
3	**Recommended prerequisites for participation** Basic courses in Communication Networks are recommended.
4	**Form of examination** Course related exam: • [20-00-0748-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading**

	Course related exam: • [20-00-0748-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 Can 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** Selected literature, details are given in lecture.

Courses

Course nr.	Course name		
20-00-0748-iv	Mobile Networking		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Thorsten Strufe		Integrated course	4

Module name					
Practical Project Telecooperation					
Module nr. 20-00-0485	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Eberhard Mühlhäuser		

1	**Teaching content** Research-related project. The students will learn to conduct their own research given an individual research project. The topics will be defined together with the adviser. Possible research topics: * Multimodale Interaction * Multitouch * Proactive Support System * Sensor Fusion
2	**Learning objectives** After successfully attending the course, students are familiar with the process of conducting research from first idea to written paper. They understand how to break down complex research questions into sub-problems and solve these problems. They are able to evaluate their system and write a report based on their findings.
3	**Recommended prerequisites for participation**
4	**Form of examination** Course related exam: • [20-00-0485-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0485-pr] (Study achievement, 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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References** Various
Courses	

	Course nr. 20-00-0485-pr	**Course name** Practical Project Telecooperation		
	Instructor Prof. Dr. rer. nat. Eberhard Mühlhäuser		**Type** Internship	**SWS** 6

Module name Network, Traffic and Quality Management for Internet Services					
Module nr. 20-00-0056	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. rer. nat. Eberhard Mühlhäuser		

1	**Teaching content** Introduction into management of Internet service provider (ISP-)networks for integrating IP service platforms with their quality and traffic profiles.
2	**Learning objectives** Course Content: Requirements and measures to ensure Quality-of-Service (QoS) • criteria from the application & user perspective (QoE: Quality of Experience). • QoS Architecture in IP Networks: Differentiated & Integrated Services • QoS support & impact per application in IP traffic mix (video streaming, VoIP, web browsing, downloads, social networking etc.) Quality Assurance for Internet Services in ISP Network Infrastructures • Network and Transport Layer Impact: Routing (OSPF, BGP), Multiprotocol Label Switching (MPLS), TCP with protection against errors and failures. • measurement, monitoring, optimization of IP traffic regarding QoS Quality assurance in service overlays and at application level • Content Delivery Networks (CDN), Clouds and Peer-to-Peer Networks (P2P) incl. distributed caches, transport path optimization, scalability • -IETF Standardization (CDN Interconnection, ALTO: Appl. Layer Traffic Opt.)
3	**Recommended prerequisites for participation** Recommended: Prerequisites: Basic knowledge in computer science and Internet applications is required. The courses on Kommunikationsnetze I and II are recommended.
4	**Form of examination** Course related exam: • [20-00-0056-vl] (Technical examination, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0056-vl] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. Informatik M.Sc. Informatik Maybe used in other degree programs.
8	**Grade bonus compliant to §25 (2)**

9	**References** Will be given in lecture.

Courses

Course nr.	Course name	
20-00-0056-vl	Network, traffic and quality management for Internet services	
Instructor	**Type**	**SWS**
	Lecture	2

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** CS, WiCS, ETiT, Wi-ETiT, BSc/MSc 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.-Ing. Ralf Steinmetz, Prof. Dr. rer. nat. Björn Scheuermann, Dr. Ing. Julian Zobel, M.Sc. Fridolin Siegmund</td><td>Type
Seminar</td><td>SWS
2</td></tr>
</table>

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

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

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, Prof. Dr. Boris Koldehofe, Prof. Dr. rer. nat. Björn Scheuermann, M.Ed. Benjamin Becker		Lecture	2

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-sm-2280-ue</td><td colspan="3">Course name
Software Defined Networking</td></tr>
<tr><td colspan="2">Instructor
Dr.-Ing. Ralf Kundel, Prof. Dr. Boris Koldehofe, Prof. Dr. rer. nat. Björn Scheuermann, M.Ed. Benjamin Becker</td><td>Type
Practice</td><td>SWS
2</td></tr>
</table>

Module name Ubiquitous computing in business processes					
Module nr. 20-00-0121	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Eberhard Mühlhäuser		

1	**Teaching content** - Learning how state-of-the-art ubiquitous computing technologies can be utilized in enterprise business processes and in the context of smart city services - Identifying technologies' economic potential for business processes and in the context of smart cities - Understanding underlying technologies, their benefits, challenges, and corresponding business cases - Technologies considered will be RFID technology and its integration with business processes, other smart items (e.g., smart shelfs), etc. - Demonstration of how integration works between the real world and the virtual world as it is represented in enterprise software systems today - Hands-on experience and live demonstrations
2	**Learning objectives** After participation in this course, students will have aquired knowledge about implications of ubiquitous computing on business to business processes and in the context of smart city services in conjunction with basic concepts.
3	**Recommended prerequisites for participation**
4	**Form of examination** Course related exam: • [20-00-0121-vl] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0121-vl] (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)**
9	**References**

	- Mühlhäuser, M.; Gurevych, I. (Eds.): Ubiquitous Computing Technology for Real Time Enterprises Information Science Reference, Dezember, 2007 - Finkenzeller, K: RFID-Handbuch. Grundlagen und praktische Anwendungen von Transpondern, kontaktlosen Chipkarten und NFC. Hanser Fachbuch; Auflage: 5., aktual. u. erw. Aufl. (1. Oktober 2008) - Fleisch, E.; Mattern, F. (Hrsg.): Das Internet der Dinge: Ubiquitous Computing und RFID in der Praxis, Springer, Berlin, Heidelberg, New York 2005 - Österle, H.; Fleisch, E.; Alt, R.: Business Networking - Shaping Collaboration between Enterprises, Springer - Callaway, E.H.: Wireless Sensor Networks: Architectures and Protocols, Auerbach Publications

Courses

Course nr.	Course name		
20-00-0121-vl	Ubiquitous computing in business processes		
Instructor		**Type**	**SWS**
		Lecture	2

Module name					
Radar Techniques					
Module nr. 18-jk-2040	**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 Jakoby		

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** MSc ETiT, MSc iCE, MSc Wi-ETiT
8	**Grade bonus compliant to §25 (2)**
9	**References** Slides, Latest Publications and Books

Courses

Course nr.	Course name		
18-jk-2040-vl	Radar Techniques		
Instructor PD Dr. habil. Holger Maune		**Type** Lecture	**SWS** 2

Module name					
Computer Networks and Distributed Systems					
Module nr. 20-00-0016	**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. phil. nat. Marc Fischlin		

1	**Teaching content** Overview of Net-Centric Computing (NCC), a basic element of modern computer science. Fundamental network concepts of modeling, planning and evaluating net-centric systems - Foundations: Service, protococols, connection, layer model - protocol mechanisms for media access, routing, broad-/multicast - Multimedia Data Handling - Aspects of continuous data streams and their processing - Quality of service: definition and mechanisms - Multimedia - Synchronisation: Basics - Compression procedures;
2	**Learning objectives** - Overview knowledge of relevant areas and basic problems of net-centric computing (NCC) - Reproducible comprehension of selected, elementary algorithms, protocols and procedures used in the internet - Applicable methodological knowledge of widely applied elements of the modeling and engineering of NCC-systems NCC is, in this context, understood as "internet technology in the broadcast sense". It covers, in particular, themes of the "classical areas" constituted by computer networks, distributed systems, multimedia and mobile communication/ mobile computing, as those from "modern areas", such as ubiquitous/pervasive computing, peer-to-peer-computing or ambient intelligence. The canonical lecture "Introduction to NCS" focusses on the area of computer networks, the understanding of which is fundamental for all other listed areas; the latter will be the subject matter of advanced lectures in the area of NCS.
3	**Recommended prerequisites for participation** Recommended: Funktionale und objektorientierte Programmierkonzepte“, „Algorithmen und Datenstrukturen“, „Betriebssysteme“, „Einführung in den Compilerbau“, „Rechnerorganisation“ und „Systemnahe and parallele Programmierung“.
4	**Form of examination** Course related exam: • [20-00-0016-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0016-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 M.Sc. Sportwissenschaft und Informatik B.Sc. Informationssystemtechnik 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** Main literature: - A. Tanenbaum, D. Wetherall: Computernetzwerke, 5te Aufl., Pearson Studium 2012 - (englisch: Computer Networks, 5th Ed., Prentics Hall 2010) - J. Kurose, K. Ross: Computernetzwerke; Pearson Studium 2012 (also in english by Prentice Hall) Selected chapters of: - G. Coulouris, J. Dollimore, T. Kindberg: Distributed Systems - Concept and Design, Pearson Studium - G. Krüger, D. Reschke: „Lehr- und Übungsbuch Telematik“ - L. Kleinrock: Queueing Systems, vol. 1 (Wiley) - W.R. Stevens: Unix Network Programming, Volume 1: The Sockets Networking API (Addison Wesley)

Courses

Course nr.	**Course name**		
20-00-0016-iv	Computer Networks and distributed Systems		
Instructor		**Type** Integrated course	**SWS** 3

Module name					
Human Computer Interaction					
Module nr. 20-00-0535	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. Bernt Schiele		

1	**Teaching content** The course presents fundamental concepts, models, and theories in the area of Human Computer Interaction (HCI). More specifically, it contains the following topics: - Theoretical foundation on psychology and interaction design as basis for the design of intuitive user interfaces - Overview of the different types of user interfaces - Command line interfaces - Graphical user interfaces (MacOS, Windows, ...) - Interactive surfaces (Tabletops, Multitouch, ...) - Mobile user interfaces (iOS, Android, ...) - Pen-based user interfaces (electronic pens) - Tangible user interfaces, organic user interfaces - Speech-based user interfaces - Evaluation, measurement and assessment of user interfaces - User studies - Quantitative evaluation - Qualitative evaluation - User-centric software development
2	**Learning objectives** After perticipation in this course, students will have - an understanding of the psychologic foundations of the design of user interfaces - know methods of the user-centric design process - aquired an overview on common UI concepts - learnt to know and how to use techniques for the evaluation of user interfaces
3	**Recommended prerequisites for participation**
4	**Form of examination** Course related exam: • [20-00-0535-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0535-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 Can 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: Selected chapters out of: • Donald Norman: The Design of Everyday Things • Alan Dix, Janet Finlay, Gregory Abowd and Russel Beale: Human-Computer Interaction • Jenny Preece , Yvonne Rogers and Helen Sharp: Interaction Design: Beyond Human-Computer Interaction			
Courses				
	Course nr. 20-00-0535-iv	**Course name** Human Computer Interaction		
	Instructor		**Type** Integrated course	**SWS** 2

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** BSc / MSc etit, BSc / MSc WI-etit, MSc MEC, MSc iST, MSc iCE
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					
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.

<table>
<tr><td>5</td><td colspan="3">Prerequisite for the award of credit points
Passing the final module examination</td></tr>
<tr><td>6</td><td colspan="3">Grading
Module exam:
• Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td colspan="3">Usability of the module
MSc etit, BSc/MSc iST, MSc iCE, MSc CE</td></tr>
<tr><td>8</td><td colspan="3">Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td colspan="3">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</td></tr>
</table>

Courses

Course nr.	Course name	Instructor	Type	SWS
18-kp-2110-vl	Data-driven Modeling - Machine Learning	Prof. Dr. techn. Heinz Köppl, Prof. Dr.-Ing. Anja Klein	Lecture	2
18-kp-2110-ue	Data-driven Modeling - Machine Learning	Prof. Dr. techn. Heinz Köppl, Prof. Dr.-Ing. Anja Klein	Practice	1
18-kp-2110-pr	Data-driven Modeling - Machine Learning Lab	Prof. Dr. techn. Heinz Köppl, Prof. Dr.-Ing. Anja Klein	Internship	1

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**	**SWS**
		Integrated course	4

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** BSc ETiT, MSc ETiT, MSc iCE
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.	Course name		
18-pr-1050-vl	Optical Communications - Components		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sascha Preu		Lecture	3

Course nr.	Course name		
18-pr-1050-ue	Optical Communications - Components		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Sascha Preu		Practice	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

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	Instructor	Type	SWS
18-zo-2110-vl	Data Science I	Dr.-Ing. Christian Debes	Lecture	2
18-zo-2110-ue	Data Science I	Dr.-Ing. Christian Debes	Practice	2

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

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

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** BSc ETiT, MSc ETiT
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, Prof. Dr.-Ing. Rolf Jakoby		Seminar	2

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** MSc (WI-) etit, BSc/MSc iST, MSc iCE
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		Practice	1

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** MSc WI-etit, BSc/Msc iST, MSc iCE
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

<table>
<tr><td colspan="6">Module name
Transport Protocols and their Design</td></tr>
<tr><td>Module nr.
18-sm-2320</td><td>Credit points
6 CP</td><td>Workload
180 h</td><td>Self-study
105 h</td><td>Module duration
1 Term</td><td>Module cycle
Irregular</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr. rer. nat. Björn Scheuermann</td></tr>
</table>

<table>
<tr><td>1</td><td>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.</td></tr>
<tr><td>2</td><td>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.</td></tr>
<tr><td>3</td><td>Recommended prerequisites for participation
Basic knowledge in the field of communication networks, as covered for instance in the module „Kommunikationsnetze 1".</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 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.</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
MSc etit, BSc/MSc iST, MSc WI-etit</td></tr>
<tr><td>8</td><td>Grade bonus compliant to §25 (2)
Yes</td></tr>
<tr><td>9</td><td>References
Technical literature will be mentioned in the lecture.</td></tr>
</table>

<table>
<tr><td colspan="4">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-sm-2320-vl</td><td colspan="2">Course name
Transport Protocols and their Design</td></tr>
<tr><td>Instructor
Prof. Dr. rer. nat. Björn Scheuermann</td><td>Type
Lecture</td><td>SWS
3</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-sm-2320-ue</td><td colspan="2">Course name
Transport Protocols and their Design</td></tr>
<tr><td>Instructor
Prof. Dr. rer. nat. Björn Scheuermann</td><td>Type
Practice</td><td>SWS
2</td></tr>
</table>

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** MSc etit, MSc WI-etit, BSc/MSc iST
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-2330-vl	Application-Layer Protocols on the Internet		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Björn Scheuermann		Lecture	3

Course nr.	**Course name**		
18-sm-2330-ue	Application-Layer Protocols on the Internet		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Björn Scheuermann		Practice	2

Module name						
One World Signal Processing Seminar Series						
Module nr. 18-pe-2090	**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. Marius Pesavento			
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** MSc etit, BSc/MSc iST, MSc WI-etit					
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		Seminar	2

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**
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 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** MSc etit, MSc iCE, BSc/Msc iST, MSc WI-etit
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	Instructor	Type	SWS
18-ad-2130-vl	Optimization in Multi-Agent Systems	Dr. rer. nat. Tatiana Tatarenko	Lecture	2
18-ad-2130-ue	Optimization in Multi-Agent Systems	Dr. rer. nat. Tatiana Tatarenko	Practice	1

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** BSc etit, BSc MEC, BSc 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 Dr.-Ing. Martin Schüßler, Prof. Dr.-Ing. Rolf Jakoby		**Type** Introductory seminar course	**SWS** 2

Module name Scientific Working and Writing					
Module nr. 18-kl-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. 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

BSc etit, BSc MEC, BSc iST

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-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

BSc etit, BSc MEC, BSc iST

8 Grade bonus compliant to §25 (2)

9 References

Courses

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

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 Prof. Dr.-Ing. Abdelhak Zoubir		**Type** Introductory seminar course	**SWS** 2

1.2 Optional Subjects SES: System on Chip and Embedded Systems

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** BSc ETiT, BSc Wi-ETiT, MSc iCE, BSc/MSc iST, BSc/MSc MEC, MSc EPE
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. 18-ho-1020-vl	**Course name** Analog Integrated Circuit Design		
	Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Lecture	**SWS** 3
	Course nr. 18-ho-1020-ue	**Course name** Analog Integrated Circuit Design		
	Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Practice	**SWS** 1

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: 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** BSc ETiT, BSc iST
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

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

Module name					
Embedded Systems Hands-On 1: Design and Implementation of Hardware-Software Systems					
Module nr. 20-00-0959	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1	**Teaching content** These labs are intended for students interested in obtaining hands-on practical experience with the design and implementation of embedded systems. The labs will begin by introducing fundamentals such as - basic electrical engineering - using lab test and measurement instruments - design and fabrication of electronic circuits - acquiring and processing data from sensors - bus protocols in embedded systems - programming and debugging heterogeneous embedded systems - the use of the Linux kernel as an operating system in an embedded context The lab core then has the participants implement a concrete embedded system. A number of possible projects will be offered, each with a different focus (e.g., hardware or software) to match student interest.
2	**Learning objectives** After successful completion, students are familiar with the practical techniques and tools required for designing, implementing and bringing-up embedded hardware/software systems. This includes basic knowledge of electrical engineering, the use of lab test and measurement instruments, the use of languages and EDA/CAD tools for hardware design. They are able to program and debug software in an embedded systems context as well as employ Linux as an operating system here.
3	**Recommended prerequisites for participation** Recommended: Successful completion of „Digital Design“, „Computer Organisation“, „Architecture and Design of Computer Systems“, „Operating Systems“ and „System-level and Parallel Programming“ or similar competencies obtained in other study programmes
4	**Form of examination** Course related exam: • [20-00-0959-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0959-pr] (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses				
	Course nr. 20-00-0959-pr	**Course name** Embedded Systems Hands-On 1: Design and Implementation of Hardware-Software Systems		
	Instructor Prof. Dr. rer. nat. Oskar von Stryk		**Type** Internship	**SWS** 4

Module name					
HDL Lab					
Module nr. 18-ho-1090	**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

Realisation of a VHDL- or Verilog-based VLSI System Design Project in a Team with industrial constraints

2 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.

3 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

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

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

8 Grade bonus compliant to §25 (2)

9 References

Lecture slides „CAD4SoC"

Courses

Course nr.	Course name		
18-ho-1090-pr	HDL Lab		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Internship	**SWS** 3

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** BSc ETiT, Wi ETiT
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 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** BSc ETiT, BSc/MSc iST
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					
High-Level Synthesis					
Module nr. 18-hb-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. 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** MSc ETiT, BSc/MSc iST, MSc iCE
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	Internship	2

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** MSc ETiT, MSc iCE, MSc 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 Prof. Dr.-Ing. Christian Hochberger		**Type** Lecture	**SWS** 2

	Course nr.	Course name		
	18-hb-2010-pr	Low-Level Synthesis		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Christian Hochberger		Internship	2

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

MSc ETiT, MSc iST, MSc Informatik, MSc iCE

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					
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** MSc ETiT, MSc iST, MSc iCE
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.-Ing. Klaus Hofmann, Prof. Dr.-Ing. Ralf Steinmetz, Prof. Dr. rer. nat. Florian Steinke, Prof. Dr.-Ing. Christian Hochberger, Prof. Dr. rer. nat. Andreas Schürr		Colloquium	2

Module name					
Advanced Topics in Embedded Systems and Applications					
Module nr. 20-00-1001	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1 Teaching content

The course covers current topics in research and development of computing systems and programming tools, including focused ones in the areas of embedded and application-specific architectures. The subjects are determined by current research efforts in the ESA group and are intended to guide students towards acquiring technical as well as introductory scientific skills, for example, including one or more of the following domains:

- Computing systems architecture at the processor and systems-level
- Design of digital electronic circuits and hardware systems
- Use of Field-Programmable Gate Arrays

Hardware/Software design and programming tools

- Operating systems and low-level programming

Hardware/Software Co-Design

Application-specific architectures and techniques

- Design and/or programming of compute accelerators
- Debugging and analysis techniques for hardware/software-systems

2 Learning objectives

Participants are intended to acquire the skills necessary to quickly become familiar with a new domain and then solve a complex practical problem within that domain. These skills can include studies of scientific literature, surveying existing code-bases from the hardware/software domains, and the practical implementation of hardware and/or software systems. The final talk should show proficiency with basic presentation techniques.

3 Recommended prerequisites for participation

An interest to develop high-quality solutions in the assigned problem domain. For different domains, different pre-requisites will be required. These can include digital design, compiler construction, system-level and parallel programming. Such skills can be acquired by successfully completing the appropriate lectures.

4 Form of examination

Course related exam:

- [20-00-1001-pp] (Study achievement, Oral/written examination, Default RS)

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:

- [20-00-1001-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

7 Usability of the module

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

8 Grade bonus compliant to §25 (2)

9 References

Courses

<table>
<tr><td rowspan="2"></td><td>Course nr.
20-00-1001-pp</td><td colspan="3">Course name
Advanced Topics in Embedded Systems and Applications</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Andreas Koch</td><td>Type
Project</td><td>SWS
6</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

MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE

8 Grade bonus compliant to §25 (2)

9 References

Slide Copies

Courses

Course nr.	Course name		
18-ho-2040-vl	Microprocessor Systems		
Instructor		**Type**	**SWS**
Dr.-Ing. Matthias Rychetsky, M.Sc. Dominik Großkurth		Lecture	2

	Course nr.	Course name		
	18-ho-2040-ue	Microprocessor Systems		
	Instructor		**Type**	**SWS**
	Dr.-Ing. Matthias Rychetsky, M.Sc. Dominik Großkurth		Practice	1

<table>
<tr><td colspan="6">Module name
Advanced Integrated Circuit Design Lab</td></tr>
<tr><td>Module nr.
18-ho-2120</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
Practical Design Tasks in Full Custom Design of Digital or Analog Ciruits using State-of-the-Art Commercial CAD Tools</td></tr>
<tr><td>2</td><td>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.</td></tr>
<tr><td>3</td><td>Recommended prerequisites for participation
Lecture "Advanced Digital Integrated Circuit Design" or “Electronic and Integrated Circuits”</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). 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
MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE</td></tr>
<tr><td>8</td><td>Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td>References
ADIC Lecture Slide Copies
• John P. Uyemura: Fundamentals of MOS Digital Integrated Circuits
• Neil Weste et al.: Principles of CMOS VLSI Design</td></tr>
</table>

<table>
<tr><td colspan="4">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-ho-2120-pr</td><td colspan="2">Course name
Advanced Integrated Circuit Design Lab</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Klaus Hofmann</td><td>Type
Internship</td><td>SWS
3</td></tr>
</table>

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** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC
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 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** MSc ETiT, MSc iST, MSc MEC, MSc Wi-ETiT, MSc iCE
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		Internship	1

Module name Labs on Computer Engineering					
Module nr. 20-00-0647	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1 Teaching content

Participants independently solve alone or in a small group an individually posed problem from the area of Computer Engineering. The problems are usually programming or hardware development tasks inspired by the research performed at the Embedded Systems and Applications Group.

2 Learning objectives

After successfully completing the labs, the participant/s is/are able to independently solve a complex problem in the field of Computer Engineering. They can evaluate the quality of their solution and compare and contrast it with other existing solutions.

3 Recommended prerequisites for participation

Depending on topic.

4 Form of examination

Course related exam:

- [20-00-0647-pr] (Study achievement, Oral/written examination, Default RS)

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:

- [20-00-0647-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

Can be used in other degree programs.

8 Grade bonus compliant to §25 (2)

9 References

Depending on topic.

Courses

Course nr.	**Course name**		
20-00-0647-pr	Practical Lab in Technical Foundations of Computer Science		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Andreas Koch		Internship	4

Module name					
Printed Electronics					
Module nr. 16-17-5110	**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. Edgar Dörsam		

1	**Teaching content** Printing technologies for functional printing (printing methods and systems); Design and materials for printed electronics (aerial, OFET, RFID); Activities for quality assurance; Examples of application (aerial, RFID, OFET, photovoltaic, batteries, lab on a chip).
2	**Learning objectives** On successful completion of this module, students should be able to: 1. Describe the printing technologies that are applicable for “Printed Electronics”. 2. Name materials that are appropriate to printing processes and to describe the impact of the materials on the design e.g. of antennas and OFETs. 3. Classify and rate different activites for quality assurance. 4. Explain basic functions, configurations, materials, and specific properties of printed antennas, RFIDs, photovoltaics and batteries. 5. Describe “Printed Electronics” as a multidisciplinary task that consists of electrical engineering, material science, and mechanical engineering.
3	**Recommended prerequisites for participation** Mechanical components and Mechatronics I and II recommended
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS) Oral exam 30 min
5	**Prerequisite for the award of credit points** Passing the examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** WPB Master MB III (Wahlfächer aus Natur- und Ingenieurwissenschaft) WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik) Master ETiT IMNT; Master Mechatronik
8	**Grade bonus compliant to §25 (2)**
9	**References** The current lecture notes can be downloaded from the web pages of the institute while the semester is in session.

Courses

Course nr.	Course name		
16-17-5110-vl	Printed Electronics		
Instructor		**Type** Lecture	**SWS** 2

Module name					
Embedded Systems Hands-On 2: Designing Hardware Accelerators for Systems-on-Chip					
Module nr. 20-00-0968	**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. Andreas Koch		

1	**Teaching content** These practical labs are intended for students interested in learning how to design hardware accelerators for systems-on-chips. It covers a wide range of topics, including - OS drivers for accelerators - design and interfacing of accelerators in Bluespec SystemVerilog - Design flows and tool chains for hardware/software co-development The actual accelerators covered are inspired by typical applications, e.g., image processing or stereovision computations.
2	**Learning objectives** Acquire skills in using the knowledge and techniques taught in prior classes to actually perform a complete hardware/software co-design of an application in an embedded systems context.
3	**Recommended prerequisites for participation** Basic knowledge using Linux on embedded Systems (e.g., acquired in ESHO1). Knowledge of the Bluespec SystemVerilog hardware description language (e.g., as taught in Architecture and Design of Computing Systems).
4	**Form of examination** Course related exam: • [20-00-0968-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0968-pr] (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		
20-00-0968-pr	Embedded Systems Hands-On 2: Designing Hardware Accelerators for Systems-on-Chip		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Andreas Koch		Internship	4

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** MSc ETiT, MSc WI-ETiT, MSc MEC, MSc Medizintechnik
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.	Course name		
	18-kn-2120-vl	Sensor Technique		
	Instructor		**Type**	**SWS**
	Prof. Dr. Mario Kupnik		Lecture	2
	Course nr.	**Course name**		
	18-kn-2120-ue	Sensor Technique		
	Instructor		**Type**	**SWS**
	Prof. Dr. Mario Kupnik		Practice	1

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** BSc etit, BSc MEC, BSc iST
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-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** BSc etit, BSc MEC, BSc iST
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					
Mastering Modern Embedded System Processors					
Module nr. 20-00-1004	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1	**Teaching content** * Processor architectures in embedded systems * ARM instruction set and microarchitecture * ARM compiler and simulator * ARM bootloading and (realtime) operating systems * ARM debugging, profiling and tracing * ARM peripheral control * ARM power management * ARM application scenarios (Cortex-M/-A/-R) * Future development of embedded processors * Recent research results
2	**Learning objectives** After successful participation, students are able to * outline the essential components and functionality of embedded processors, * differentiate the advantages and disadvantages of different processor architectures, * use relevant development tools for embedded processors, * examine the functionality and efficiency of existing source code, * develop efficient source code for specific applications, * assess recent embedded systems research results.
3	**Recommended prerequisites for participation** Successful participation in "Rechnerorganisation" or similar
4	**Form of examination** Course related exam: • [20-00-1004-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1004-iv] (Technical examination, 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**
Courses	

	Course nr.	Course name		
	20-00-1004-iv	Mastering Modern Embedded System Processors		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Andreas Koch		Integrated course	3

Module name					
Practical Programming of FPGAs using High-Level Languages					
Module nr. 20-00-1081	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1 Teaching content

FPGAs have been used very successfully in recent years to implement application-specific accelerators in heterogeneous systems. However, programming with conventional hardware description languages such as Verilog or VHDL is still the norm.

As an alternative, high-level synthesis tools that can also generate hardware from high-level languages such as C/C++ play an increasingly important role in the implementation of such accelerators. During this course you will gain useful background knowledge on the basic algorithms of high-level synthesis as well as knowledge in practical design and optimization of FPGA designs using high-level synthesis tools.

In addition, you will learn relevant techniques for the integration of FPGA-based accelerators into heterogeneous systems. During the practical phase of this course, you will create an FPGA-based accelerator for a given problem and implement it on a typical heterogeneous system in real hardware.

2 Learning objectives

- Understanding the basics of HLS systems

- Understanding of important internals of HLS systems (e.g. optimization, scheduling)

- Ability to design high-level language hardware accelerators and use HLS systems to generate executable FPGA designs

- Experience in troubleshooting and optimization of HLS generated hardware designs

- Experience in the integration of hardware accelerators into heterogeneous computing systems using hardware/software co-design tools.

3 Recommended prerequisites for participation

- Basics of Digital Logic (DT))

- Basics of Computer Architecture (Computer Organization RO, Architecture and Design of Computer Systems (AER)

- Basic knowledge of compilers is dvantageous, but not obligatory

- Using Linux systems and virtual machines

4 Form of examination

Course related exam:
- [20-00-1081-iv] (Technical examination, Oral/written examination, Default RS)

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

	Course related exam: • [20-00-1081-iv] (Technical examination, 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**

Courses

Course nr.	Course name		
20-00-1081-iv	Practical Programming of FPGAs using High-Level Languages		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Andreas Koch		Integrated course	2

<table>
<tr><td colspan="6">Module name
Hardware for Neural Networks</td></tr>
<tr><td>Module nr.
18-zh-2010</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
English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Li Zhang</td></tr>
</table>

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: 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** MSc etit, MSc WI-etit, BSc/MSc iST, MSc iCE
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	Internship	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** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC
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 Prof. Dr.-Ing. Klaus Hofmann		**Type** Seminar	**SWS** 3

<table>
<tr><td colspan="7">Module name
Modelling and Simulation of Circuits</td></tr>
<tr><td colspan="2">Module nr.
18-sc-2010</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="4">Language
German/English</td><td colspan="3">Module owner
Prof. Dr. rer. nat. Sebastian Schöps</td></tr>
<tr><td>1</td><td colspan="6">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</td></tr>
<tr><td>2</td><td colspan="6">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.</td></tr>
<tr><td>3</td><td colspan="6">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</td></tr>
<tr><td>4</td><td colspan="6">Form of examination
Module exam:
Module exam (Technical examination, Oral examination, Duration: 20 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
BSc/MSc etit, BSc/MSc iST, BSc MEC, MSc iCE, MSc WI-etit</td></tr>
<tr><td>8</td><td colspan="6">Grade bonus compliant to §25 (2)
Grade bonus of 0,4 if correctly implemented programs are submitted</td></tr>
<tr><td>9</td><td colspan="6">References</td></tr>
</table>

- 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	Type	SWS
18-sc-2010-vl	Modelling and simulation of circuits		
Instructor		Lecture	2
18-sc-2010-ue	Modelling and simulation of circuits		
Instructor		Practice	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** MSc ETiT, M.Sc. iCE, M.Sc. MEC
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

1.3 Optional Subjects SWE: Software-Engineering

Module name C/C++ Programming Lab					
Module nr. 18-su-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. 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** BSc ETiT, BSc MEC, BSc iST, BSc 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-su-1030-pr	C/C++ Programming Lab

Instructor	Type	SWS
Prof. Dr. rer. nat. Andreas Schürr	Internship	2

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** MSc ETiT, BSc iST, MSc Wi-ETiT, BSc Informatik
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 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

BSc ETiT, MSc ETiT, BSc iST

8 Grade bonus compliant to §25 (2)

9 References

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

Courses

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-su-1060-pj</td><td colspan="3">Course name
Projektseminar Software Systems</td></tr>
<tr><td colspan="2">Instructor
M.Sc. Lars Luthmann, Prof. Dr. rer. nat. Andreas Schürr</td><td>Type
Project seminar</td><td>SWS
4</td></tr>
</table>

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 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

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

<table>
<tr><td colspan="6">Module name
Multithreading in C++</td></tr>
<tr><td>Module nr.
20-00-0953</td><td>Credit points
10 CP</td><td>Workload
300 h</td><td>Self-study
210 h</td><td>Module duration
1 Term</td><td>Module cycle
Every 2. Semester</td></tr>
<tr><td colspan="3">Language
German/English</td><td colspan="3">Module owner
Prof. Dr. rer. nat. Oskar von Stryk</td></tr>
</table>

<table>
<tr><td>1</td><td>Teaching content
C++ offers one of the most advanced threading interfaces available today. Using this interface as an example, the course teaches how to develop parallel software for shared memory with threads.
• Shared memory architectures
• Managing threads
• Sharing data between threads
• Synchronizing concurrent operations
• Designing lock-based concurrent data structures
• Designing programs for concurrency
• Testing and debugging</td></tr>
<tr><td>2</td><td>Learning objectives
Skill of developing parallel programs
• Systematically develop correct and efficient multithreaded programs
• Design and implement parallel data structures</td></tr>
<tr><td>3</td><td>Recommended prerequisites for participation
• Knowledge of C/C++</td></tr>
<tr><td>4</td><td>Form of examination
Course related exam:
• [20-00-0953-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%)

Students which passed 20-00-0801 aren't allowed in this lecturen.</td></tr>
<tr><td>6</td><td>Grading
Course related exam:
• [20-00-0953-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</td></tr>
</table>

<table>
<tr><td colspan="4">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
20-00-0953-iv</td><td colspan="2">Course name
Multithreading in C++</td></tr>
<tr><td>Instructor
Prof. Dr. rer. nat. Oskar von Stryk</td><td>Type
Integrated course</td><td>SWS
6</td></tr>
</table>

Module name					
Advanced Compiler Construction					
Module nr. 20-00-0701	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1	**Teaching content** - Compilation and run-time environment for object-oriented programming languages - Control flow graphs as intermediate representations - Static dataflow analysis - Static single-assignment form - Eliminating total and partial redundancy - Scalar optimization - Register allocation - Scheduling - Loop optimization - Structure and organization of real compilers (e.g., phases, intermediate representations, compfile flow)
2	**Learning objectives** After successfully attending the course, students understand techniques for the compilation and execution of object-oriented programs at the machine-level. The can apply static dataflow analysis to control flow graphs and are practiced using their SSA form. They are familiar with optimizing techniques for a number of problems as well as fundamental algorithms for register allocation. They know the internal structure of real production-grade compilers.
3	**Recommended prerequisites for participation** Successfull participation of “Einführung in den Compilerbau”
4	**Form of examination** Course related exam: • [20-00-0701-vl] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0701-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 Can 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: Cooper/Torczon: Engineering a Compiler Muchnick: Advanced Compiler Design and Implementation Aho/Lam/Sethi/Ullman: Compilers - Principles, Techniques, and Tools

Courses

Course nr.	Course name		
20-00-0701-vl	Advanced Compiler Construction		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Andreas Koch		Lecture	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** MSc ETiT, BSc 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

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.	**Course name**		
18-su-2100-pj	Autonomous Driving Lab II		
Instructor		**Type**	**SWS**
Dr. Ing. Eric Lenz		Project seminar	3

Module name					
Advanced Multithreading in C++					
Module nr. 20-00-0977	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1	**Teaching content** C++ offers one of the most modern threading interfaces available today. Using this interface as an example, the course teaches advanced techniques to develop parallel software for shared memory with threads. Based on the contents of the course Multithreading in C++, this course will cover the following topics: • C++ memory model and atomic operations • Designing lock-free concurrent data structures • Advanced thread management (e.g., thread pools)
2	**Learning objectives** After successfully completing the course, the students have advanced skills of developing parallel programs. They are able to - Systematically develop correct and efficient multithreaded programs - Design and implement parallel data structures
3	**Recommended prerequisites for participation** • Knowledge of C/C++ • Foundations of programming threads in C++ (lock-based synchronization and lock-based concurrent data structures)
4	**Form of examination** Course related exam: • [20-00-0977-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%) Students who passed Modul "Fortgeschrittene parallele Programmierung 2" (FPPROG2), 20-00-0938 aren't allowed to pass this Modul.
6	**Grading** Course related exam: • [20-00-0977-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
20-00-0977-iv	Advanced Multithreading in C++		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Oskar von Stryk		Integrated course	4

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

BSc iST, BSc Informatik, MSc 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-2080-se	Seminar Software System Technology		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Andreas Schürr		Seminar	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

MSc etit, MSc CE; BSc/MSc WI-etit, BSc/MSc iST

<table>
<tr><td>8</td><td colspan="4">Grade bonus compliant to §25 (2)
Yes. An earned bonus is creditable until the exercises are offered again.</td></tr>
<tr><td>9</td><td colspan="4">References
Will be handed out during the lecture and is provided via Moodle.</td></tr>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-sc-2050-vl</td><td colspan="3">Course name
Introduction to Scientific Computing in C++</td></tr>
<tr><td colspan="2">Instructor
Dr. Manuel Baumann, Dr. Felix Wolf</td><td>Type
Lecture</td><td>SWS
2</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-sc-2050-ue</td><td colspan="3">Course name
Introduction to Scientific Computing in C++</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Practice</td><td>SWS
2</td></tr>
</table>

Module name Optimizing Compiler Project					
Module nr. 20-00-0498	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1	**Teaching content** - Compiler implementation in Java - Modification of an existing compiler - Extension by a new intermediate representation - scalar optimizations on new IR
2	**Learning objectives**
3	**Recommended prerequisites for participation** The lectures Optimizing Compilers in the same term.
4	**Form of examination** Course related exam: • [20-00-0498-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0498-pr] (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**		
20-00-0498-pr	Praktikum Optimierende Compiler		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Andreas Koch		Internship	2

Module name Formal Principles of Computer Science III					
Module nr. 20-00-0003	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. phil. nat. Marc Fischlin		

1	**Teaching content** The course is given in German
2	**Learning objectives** The course is given in German
3	**Recommended prerequisites for participation** The course is given in German
4	**Form of examination** Course related exam: • [20-00-0901-iv] (Technical examination, Oral/written examination, Default RS) • [20-00-0901-iv] (Study achievement, Oral/written examination, p/np RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0901-iv] (Technical examination, Oral/written examination, Weighting: 100 %) • [20-00-0901-iv] (Study achievement, Oral/written examination, Weighting: 0 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
20-00-0901-iv	Formale Methods in Software Design		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Andreas Koch		Integrated course	3

Module name Concepts of Programming Languages					
Module nr. 20-00-0072	**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. Ermira Mezini		

1 Teaching content

Fundamental concepts of programming languages. In particular, we identify various basic concepts of programming languages and discuss them in detail, for example:

- role of syntax
- functions
- meta-interpreters
- recursion
- lazy evaluation
- state and side effects
- continuations
- domain-specific languages and macros
- object-oriented programming

2 Learning objectives

After the successful completion of the lecture, students will be able to perform the following tasks:

- they will be able to identify the defining features of programming languages;
- they will be familiar with fundamental theoretical concepts of programming languages;
- they will be able to implement simple programming languages using different implementation techniques;
- students will understand the influence of different programming languages on the solution space of various software development problems;
- students will be able to overcome stereotypical categorizations of programming languages.

3 Recommended prerequisites for participation

Recommended: Funktionale und Objektorientierte Programmierkonzepte

4 Form of examination

Course related exam:

- [20-00-0072-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:

- [20-00-0072-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

	B. Sc. Informatik M. Sc. Informatik M. Sc. Computer Science M. Sc. Autonome Systeme und Robotik M.Sc. IT Sicherheit M.Sc. IT Security 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** • S. Krishnamurthi: Programming Languages - Application and Interpretation • M. Scott: Programming Language Pragmatics, Morgan Kaufmann • D. Friedman et al.: Programming Language Essentials, MIT Press

Courses

Course nr.	Course name		
20-00-0072-iv	Concepts of Programming Languages		
Instructor		**Type**	**SWS**
		Integrated course	4

Module name					
Compiler Construction Lab					
Module nr. 20-00-0911	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1	**Teaching content** Independently implement a compiler or extend an existing compile flow (e.g., realize new optimization passes or back-ends).
2	**Learning objectives** After successfully completing the labs, students are able to independently implement core parts of a modern compiler, either from scratch or integrating them into an existing compiler framework. In this process, they can apply and improve their knowledge both of compiler technology (e.g, use of different intermediate representations), as well as of general implementation techniques (e.g., applying design patterns).
3	**Recommended prerequisites for participation** Recommended: Participation of lecture „Rechnerorganisation“, „Einführung in den Compilerbau“ and „Fortgeschrittener Compilerbau“, respectively according knowledge.
4	**Form of examination** Course related exam: • [20-00-0911-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0911-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 M.Sc. Informationssystemtechnik May be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be given to actual topic.
Courses	

	Course nr.	Course name		
	20-00-0911-pr	Compiler Construction Lab		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Ermira Mezini		Internship	4

Module name Modeling, Specification and Semantics					
Module nr. 20-00-0013	**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

- Models and their significance for Computer Science
- Introduction to discrete modeling using mathematical logic and algebraic concepts
- Interpretation and faithfulness of formal models
- Abstraction, refinement, composition, and decomposition of models
- Systematic construction of models and deliberate design decisions
- Syntax and operational semantics of programming languages
- Introduction to specification languages
- Syntax and denotational semantics of formal specification languages
- Elementary proof techniques and their use
- Modeling of systems and of requirements
- Modeling of coordination and communication in concurrent systems

2 Learning objectives

After successfully completing this module, students know basic concepts and methods of modeling, specification, and semantics. They are able to use predicate logic and algebraic concepts to formalize informally described scenarios and to assess the faithfulness of formal system models. They are able to develop discrete models in a systematic fashion, to make necessary design decisions, and to employ informal notation and graphics to facilitate the construction of formal models. They know selected formal specification languages and are able to use at least one such language. They understand the distinction between the syntax and semantics of formal languages, and they are able to prove propositions about concrete programs and specifications as well as simple meta-properties about programming and specification languages. They are able to formalize basic system requirements and can assess the faithfulness of such formalizations.

3 Recommended prerequisites for participation

Recommended:
Participation of lecture “Automaten, formale Sprachen und Entscheidbarkeit” and “Aussagen- und Prädikatenlogik”, respective according knowledge.

4 Form of examination

Course related exam:
- [20-00-0013-iv] (Technical examination, Oral/written examination, Default RS)

Written Exam (90 min.)

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:
- [20-00-0013-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B. Sc. Informatik
Lehramt an Gymnasien - Fach 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** U. Kastens, H. Kleine Büning: Modellierung - Grundlagen und formale Methoden, Hanser G. Winskel: The Formal Semantics of Programming Languages, MIT Press C. A. R. Hoare: Communicating Sequential Processes, Prentice-Hall Literature recommendations will be updated regularly.

Courses

Course nr.	Course name		
20-00-0013-iv	Modellierung, Spezifikation und Semantik		
Instructor		**Type**	**SWS**
		Integrated course	3

Module name					
Software Engineering for Artificial Intelligence					
Module nr. 20-00-1097	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1	**Teaching content** Data-driven artificial intelligence (AI) solutions are being adopted in many areas, including finance, medicine, cognitive sciences, and biology. Such machine learning (ML) approaches require an accurate domain and requirement analysis, proper software design and development, dedicated testing and debugging, as well as specific techniques that ensure scalability and maintainability. While AI-enabled systems continue to have a tremendous impact on many fields, developers and data scientists still follow methods (scripting, informal/non-written specifications, trial-and-error testing) that do not conform to the state of the art of engineering disciplines. In this context, it is of paramount importance to take advantage of the decades-long developments of software engineering (SE) to systematize the development process of ML solutions. In this course, each student will be assigned a topic regarding SE for AI. Based on provided resources and personal extending research, each student prepares a presentation with following discussion. These will be conducted in regular appointments. The students not presenting at a particular date, prepare via introductory reading for the respective discussion. Grading will be based on the preparation of the assigned topic and its presentation, as well as on the participation in all the discussions. For more information and announcements, please consult the course webpage: https://allprojects.github.io/SE4AI/
2	**Learning objectives** After successful completion of the module students will have developed a deeper understanding of software engineering for artificial intelligence. This includes the key topics requirements engineering, quality assurance, development processes, and software architecture and design accounting for modularity, reusability, efficiency, scalability, fairness and privacy. The students learn the preparation and the presentation of scientific contents for an audience with heterogeneous background knowledge. Moreover, students train efficient preparation of and active participation in scientific discussions as well as their moderation.
3	**Recommended prerequisites for participation** Recommended: Basic knowledge of software engineering. Interest in artificial intelligence.
4	**Form of examination** Course related exam: • [20-00-1097-se] (Study achievement, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible: Colloquium (optional: including presentation).
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1097-se] (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**

Courses

Course nr.	Course name		
20-00-1097-se	Software Engineering for Artificial Intelligence		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ermira Mezini		Seminar	3

Module name					
Static and Dynamic Program Analysis					
Module nr. 20-00-0580	**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.-Ing. Heiko Mantel		

1 Teaching content

- operational semantics for sequential and parallel programs
- overview of techniques for static and dynamic program analysis
- abstract interpretation
- data flow analysis
- slicing techniques
- type-based program analysis
- concepts of runtime monitoring
- techniques for implementing runtime monitoring
- language-based security
- soundness and precision of program analysis

2 Learning objectives

After successfully participating in this course the students will know a range of different program analyses. The students will understand the functionality of each program analysis and the difference between each of the considered program analyses. Furthermore, the students will be able to judge which program analysis is suitable for a specific problem, and they will be able to apply the different program analyses. The students will also be able to judge the precision and soundness of program analyses. Finally, the students will be able to implement and define the considered program analyses and variants of them.

3 Recommended prerequisites for participation

Knowledge of Computer Science and Mathematics equivalent to the first four semesters in the Computer Science Bachelor program, in particular basic knowledge about logic and the ability to understand formal calculi.

4 Form of examination

Course related exam:

- [20-00-0580-iv] (Technical examination, Oral/written examination, Default RS)

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:

- [20-00-0580-iv] (Technical examination, 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

Courses

	Course nr.	Course name		
	20-00-0580-iv	Static and Dynamic Program Analysis		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Heiko Mantel		Integrated course	4

Module name Data Management - Lab					
Module nr. 20-00-1041	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	**Teaching content** Participants independently solve alone or in a small group an individually a given problem. The problems are usually programming projects inspired by the research performed at the Data Management Lab. Possible areas are: - Scalable Databases & Modern Hardware - Cloud Databases & Blockchains - Interactive Data and Text Exploration - Natural Language Interfaces for Databases - Scalable Systems for Machine Learning In this lab the students will realise a project defined by their advisor. Compared to the "Data Management - Lab", the “Data Management - Extended Lab” requires more effort.
2	**Learning objectives** After completion of this course the students are able to - Understand state-of-the-art techniques in modern data management systems - Apply and implemenation of techniques in individual projects - Provide experimental evidence for design decisions with benchmarks and/or real workloads
3	**Recommended prerequisites for participation** Depending on selected topic.
4	**Form of examination** Course related exam: • [20-00-1041-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1041-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**

Courses

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

Module name Data Management - Extended Lab					
Module nr. 20-00-1042	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	**Teaching content** Participants independently solve alone or in a small group an individually a given problem. The problems are usually programming projects inspired by the research performed at the Data Management Lab. Possible areas are: - Scalable Databases & Modern Hardware - Cloud Databases & Blockchains - Interactive Data and Text Exploration - Natural Language Interfaces for Databases - Scalable Systems for Machine Learning In this lab the students will realise a project defined by their advisor. Compared to the "Data Management - Lab", the “Data Management - Extended Lab” requires more effort.
2	**Learning objectives** After completion of this course the students are able to - Understand state-of-the-art techniques in modern data management systems - Apply and implemenation of techniques in individual projects - Provide experimental evidence for design decisions with benchmarks and/or real workloads
3	**Recommended prerequisites for participation** Depending on selected topic.
4	**Form of examination** Course related exam: • [20-00-1042-pp] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1042-pp] (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**
Courses	

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

Module name Scalable Data Management Systems					
Module nr. 20-00-1017	**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. techn. Johannes Fürnkranz		

1	**Teaching content** This course introduces the fundamental concepts and computational paradigms of scalable data management systems. The focus of this course is on the systems-oriented aspects and internals of such systems for storing, updating, querying, and analyzing large datasets. Topics include: Database Architectures Parallel and Distributed Databases Data Warehousing MapReduce and Hadoop Spark and its Ecosystem Optional: NoSQL Databases, Stream Processing, Graph Databases, Scalable Machine Learning
2	**Learning objectives** After the course the student will have a good overview of the different concepts, algorithms, and systems aspects of scalable data management. The main goal is that the students will know how to design and implement such systems including hands-on experience with state-of-the-art systems such as Spark.
3	**Recommended prerequisites for participation** Programming in C++ and Java Informationsmanagement (20-00-0015-iv) Optional: Foundations of Distributed Systems (20-00-0998-iv)
4	**Form of examination** Course related exam: • [20-00-1017-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1017-iv] (Technical examination, 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**
Courses	

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

Module name					
Advanced Data Management Systems					
Module nr. 20-00-1039	**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. techn. Johannes Fürnkranz		

1 Teaching content

This is an advanced course about the design of modern data management systems which has a heavy emphasis on system design and internals. Sample topics include modern hardware for data management, main memory optimisations, parallel and approximate query processing, etc.

The course expects the reading of research papers (SIGMOD, VLDB, etc.) for each class. Programming projects will implement concepts discussed in selected papers. The final grade will be based on the results of the programming projects. There will be no final exam.

2 Learning objectives

Upon successful completion of this course, the student should be able to:
- Understand state-of-the-art techniques for modern data management systems
- Discuss design decision of modern data management systems with emphasis on constructive improvements
- Implement advanced data management techniques and provide experimental evidence for design decisions

3 Recommended prerequisites for participation

Solid Programming skills in C and C++
Scalable Data Management (20-00-1017-iv)
Information Management (20-00-0015-iv)

4 Form of examination

Course related exam:
- [20-00-1039-iv] (Technical examination, Oral/written examination, Default RS)

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:
- [20-00-1039-iv] (Technical examination, 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

Courses

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

2 Applications

2.1 Optional Subjects AIS-AS: Automotive Systems

<table>
<tr><td colspan="6">Module name
System Dynamics and Automatic Control Systems I</td></tr>
<tr><td>Module nr.
18-fi-1010</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
Winter term</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr.-Ing. Rolf Findeisen</td></tr>
</table>

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**
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.	Course name		
18-fi-1010-vl	System Dynamics and Automatic Control Systems I		
Instructor		**Type**	**SWS**
M.Sc. Florian Weigand, Prof. Dr.-Ing. Rolf Findeisen		Lecture	3

Course nr.	Course name		
18-fi-1010-tt	System Dynamics and Automatic Control Systems I- Auditorium Exercise		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Rolf Findeisen		Tutorial	1

<table>
<tr><td colspan="6">Module name
Technical Thermodynamics I</td></tr>
<tr><td>Module nr.
16-14-5010</td><td>Credit points
6 CP</td><td>Workload
180 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. Dr.-Ing. Peter Stephan</td></tr>
</table>

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 Motor Vehicles					
Module nr. 16-27-5010	**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. Steven Peters		

1	**Teaching content** Layout and function of vehicle components (e.g. engine, transmission, chassis, tires, breaks, steering); driving resistance & performance; safety; aerodynamics and automotive computing.
2	**Learning objectives** On successful completion of this module, students should be able to: 1. Calculate the factors that influence fuel consumption and discuss the strategies to reduce fuel consumption. 2. Derive upper bounds for combustion engine efficiencies and discuss the future opportunities & challenges of electromobility. 3. Explain the basic requirements, working principles, and basic structure of the drivetrain, powertrain, and chassis assemblies (including tires, wheels, brakes, steering, springs, dampers and axles). 4. Name and explain the methods to increase safety in individual traffic. 5. Explain the effects of aerodynamic measures on driving dynamics and fuel consumption.
3	**Recommended prerequisites for participation** Basic knowledge of technical mechanics (force diagram, equations of motion) and basic knowledge of thermodynamics recommended.
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** WP Bachelor MB Bachelor Mechatronik MSc. Informatik (Anwendungsfach Fahrzeugtechnik, Spezialisierung)
8	**Grade bonus compliant to §25 (2)**
9	**References** Manuscript, CD-ROM (can be purchased at the department's office), internet download

Courses

Course nr.	Course name		
16-27-5010-vl	Motor Vehicles		
Instructor		**Type** Lecture	**SWS** 3

	Course nr.	Course name		
	16-27-5010-ue	Motor Vehicles		
	Instructor		**Type** Practice	**SWS** 2

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** BSc 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		Internship	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** BSc ETiT; BSc MEC
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**
M.Sc. Alexander Steinke, Prof. Dr.-Ing. Rolf Findeisen		Internship	3

<table>
<tr><td colspan="6">Module name
Ride and Handling</td></tr>
<tr><td>Module nr.
16-27-5020</td><td>Credit points
6 CP</td><td>Workload
180 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. Dr.-Ing. Steven Peters</td></tr>
<tr><td>1</td><td colspan="5">Teaching content
Longitudinal and lateral dynamics; vehicle dynamics control; handling & comfort; suspension & body control; testing & calibration</td></tr>
<tr><td>2</td><td colspan="5">Learning objectives
On successful completion of this module, students should be able to:
1. Derive vehicle longitudinal dynamics from driving and frictional conditions as well as from the design.
2. Employ the basic equations of lateral dynamics with the fundamental motion and force dimensions of the single-track model and describe and assess vehicle behaviour at steady state skidpad testing as well as at load changes during curve-driving.
3. Discuss measures which influence a vehicle's self-steering properties. Discuss measures to influence self-steering behavior
4. Explain the transmission of lateral forces between the road and tyre and discuss the interaction between longitudinal and lateral forces.
5. Explain the principal ESP estimation and control processes incl. their meaning regarding to vehicle dynamics control.
6. Discuss challenges as well as opportunities for driving dynamics of battery electric vehicles.
7. List steady and unsteady state road trials for handling and assessment and refer to results of road trials for making conclusions about handling characteristics.</td></tr>
<tr><td>3</td><td colspan="5">Recommended prerequisites for participation
Fundamentals of automotive engineering, basic knowledge of technical mechanics (force diagram, equations of motion), basic knowledge of thermodynamics, basic knowledge of vibrations recommended</td></tr>
<tr><td>4</td><td colspan="5">Form of examination
Module exam:
• Module exam (Technical examination, Oral/written examination, Default RS)
Written Exam 90 min or oral Exam 45 min</td></tr>
<tr><td>5</td><td colspan="5">Prerequisite for the award of credit points
Passing the examination</td></tr>
<tr><td>6</td><td colspan="5">Grading
Module exam:
• Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td colspan="5">Usability of the module
WPB Master MB II (Kernlehrveranstaltung aus dem Maschinenbau)
Master MB II SP FAS
WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)
WI/MB, MSc Traffic&Transport, (Vertiefungsmodul FB16, ggf. Auflage), Master Mechatronik, MSc. Informatik (Anwendungsfach Fahrzeugtechnik, Spezialisierung)</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
manuscript, e-Learning Materials via Moodle</td></tr>
<tr><td colspan="6">Courses</td></tr>
</table>

	Course nr. 16-27-5020-vl	**Course name** Ride and Handling		
	Instructor		**Type** Lecture	**SWS** 3
	Course nr. 16-27-5020-ue	**Course name** Ride and Handling		
	Instructor		**Type** Practice	**SWS** 2

<table>
<tr><td colspan="7">Module name
Trends in Automotive Engineering (a unite!-Lecture)</td></tr>
<tr><td colspan="2">Module nr.
16-27-5030</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
Summer term</td></tr>
<tr><td colspan="4">Language
English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Steven Peters</td></tr>
<tr><td>1</td><td colspan="6">Teaching content
This (usually virtually offered) "European Lecture" covers development trends in the global automotive industry and current research topics of vehicle technology institutes in unite!: system and function development in advanced driving assistance systems or automated driving systems, sustainable powertrain technology, etc.</td></tr>
<tr><td>2</td><td colspan="6">Learning objectives
On successful completion of this module, students should be able to:
1. Report and discuss about present and forward-looking technologies in the fields of driver assistance systems and automated driving technology as well as sustainable powertrain solutions.
2. Explain current developments.
3. Evaluate possibilities and limitations of distinct approaches.</td></tr>
<tr><td>3</td><td colspan="6">Recommended prerequisites for participation
Fundamentals of automotive engineering recommended</td></tr>
<tr><td>4</td><td colspan="6">Form of examination
Module exam:
• Module exam (Technical examination, Oral/written examination, Default RS)
Written exam 90 min or oral exam 30 min.</td></tr>
<tr><td>5</td><td colspan="6">Prerequisite for the award of credit points
Passing the examination.</td></tr>
<tr><td>6</td><td colspan="6">Grading
Module exam:
• Module exam (Technical examination, Oral/written examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td colspan="6">Usability of the module
WPB Master MB III (Wahlfächer aus Natur- und Ingenieurwissenschaft)
WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)
Master Mechatronik, MSc. Informatik (Anwendungsfach Fahrzeugtechnik, Spezialisierung), MSc Traffic&Transport, (Vertiefungsmodul FB16, ggf. Auflage)</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
Manuscript, e-Learning Materials via Moodle</td></tr>
<tr><td colspan="7">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
16-27-5030-vl</td><td colspan="5">Course name
Trends in Automotive Engineering (a unite!-Lecture)</td></tr>
<tr><td colspan="4">Instructor</td><td>Type
Lecture</td><td>SWS
2</td></tr>
</table>

Module name					
ADP (6 CP) Automotive Engineering					
Module nr. 16-27-a061	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr.-Ing. Steven Peters		

1	**Teaching content** Current research topic from the general area of the administering institute.
2	**Learning objectives** The students become acquainted with teamwork and are able to take over responsibility for leading tasks within the team. They learn to assess divergent positions and the necessity of common agreements in interpersonal relationships as well as typical engineering challenges in a positive manner. They are able to recognize and specify complex problems and to distinguish between different solutions. They also study how to valuate the importance of an exact time and work schedule positively.
3	**Recommended prerequisites for participation** Possible prerequisites will be prescribed by the individual institute supervising the project.
4	**Form of examination** Module exam: • Module exam (Technical examination, Special form, Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Special form, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References** will depend on topic; available upon announcement
Courses	

Module name Avionics System Safety					
Module nr. 16-23-5110	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Uwe Klingauf		

1	**Teaching content** Operational requirements for flight guidance systems, structure of flight guidance systems, architectures and design of safe systems, pilot assistance systems in the cockpit, human factors.
2	**Learning objectives** On successful completion of this module, students should be able to: 1. Describe the basics of automated flight operations and human-machine interfaces in modern aircraft flight decks. 2. Explain the basic concepts and methods in the design of safety critical systems in flight control. 3. Differentiate between the different system architecture concepts. 4. Describe and discuss the complex interplay of technical systems, operational processes and humans using the example of avionics systems.
3	**Recommended prerequisites for participation** Recommended: Flight Mechanics I: Performance, Fundamentals of Navigation I, Systemic Evaluation of Air Transportation
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Default RS) Written exam 60 min or oral exam 20 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** WPB Master MB II (Kernlehrveranstaltung aus dem Maschinenbau) Master AE II Kernlehrveranstaltung WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)
8	**Grade bonus compliant to §25 (2)**
9	**References** Bahr, N.J.: System Safety Engineering and Risk Assessment: A Practical Approach, 2ndEdition, CRC Press 2015Dhillon, B.S.: Transportation Systems Reliability and Safety, CRC Press 2011C.C. Rodriges, S.K. Cusick: Commercial Aviation Safety, McGraw Hill 2011R. Isermann: Fault Diagnosis Systems, Springer 2006

Courses

Course nr.	Course name		
16-23-5110-vl	Avionics System Safety		
Instructor		**Type** Lecture	**SWS** 2

Module name Combustion Engines I					
Module nr. 16-03-5010	**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. techn. Christian Beidl		

1	**Teaching content** Introduction: Historic review, economic and ecological aspects, classification of engines. Fundamentals of the thermodynamic process: Carnot cycle, constant-volume cycle, constant-pressure cycle, Seiliger cycle. Fundamentals of engine construction: Crank shaft, con-rod, bearing, piston, piston rings, piston pin, liner, cylinder head gasket, cylinder head, charge cycle. Parameters: Mean pressure, power, torque, fuel consumption, efficiency, cylinder charge, air fuel ratio, kinematics of the crank mechanism, compression ratio, characteristic diagrams, main dimensions. Fuel: Chemical configuration, characteristics, heat value, characteristics of ignition, production, alternative fuels. Basics of carburation: Spark-ignition engines, diesel engines, spreading, conditioning. Carburation of spark-ignition engines: Carburator, electronic fuel injection, HCCI (Homogeneous Charge Compression Ignition). Ignition of spark-ignition engines: Requirements, spark plug, ignition systems, magnetic systems, knock control systems.Mixture formation of diesel engines: basics, classification of different methods, mixture distribution and mixture formation, injection systems.
2	**Learning objectives** On successful completion of this module, students should be able to: 1. Explain the principles and the construction of combustion engines (ranging from small two-stroke models to the marine diesel engine). 2. Explain the physical principles of combustion engines. 3. Develop the essential parameters and apply these to characterise engines. 4. Explain the economic and ecological relevance of combustion engines. 5. Apply the thermodynamic basics of combustion engines to develop new drive concepts. 6. Describe the basics of the engine construction. 7. Analyse and evaluate the interdependency of fuel, mixture formation, and combustion. 8. Explain the difference by mixture formation and ignition process of spark ignited engines and diesel engines. 9. Explain the ignition and ignition systems of the spark ignited engine.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Default RS) Written or oral exam [written: 90 min; oral: 90 min (per group with 4 people 22,5 min per participiant). 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 Bachelor Mechatronik
8	**Grade bonus compliant to §25 (2)**
9	**References** VKM I - script, available at the secretariat

Courses

Course nr.	Course name		
16-03-5010-vl	Combustion Engines I		
Instructor		**Type**	**SWS**
		Lecture	3

Module name					
Automotive Mechatronics and Assistance Systems					
Module nr. 16-27-5040	**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. Steven Peters		

1	**Teaching content** Sensors for advanced driver assistance systems (ultrasonic, radar, lidar, camera, ...); longitudinal control assistance; lateral control assistance; active collision protection systems; navigation; automated driving (AI and safety)
2	**Learning objectives** On successful completion of this module, students should be able to: 1. Indicate special difficulties at recognising the vehicle's surrounding field and describe the consequences of these difficulties for the system utilisation. 2. Explain the effect chain of the sensors from detection over perception up to surrounding field representation for ultrasonic, radar, lidar, and video. 3. Describe the basic functions and the function limits of automatically acting driver assistance systems and collision mitigation systems. 4. Evaluate the benefits and modes of action of vehicle safety systems and illustrate the course of an accident and describe a crash test. 5. Illustrate the function of the modules necessary in the vehicle for navigation. 6. Decipt challenges of automated driving in passenger cars and trucks and discuss risk minimal introduction paths.
3	**Recommended prerequisites for participation** Fundamentals of automotive engineering recommended
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Default RS) Written exam 90 min or oral exam 45 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** WPB Master MB II (Kernlehrveranstaltung aus dem Maschinenbau) Master MB II FAS Pflicht WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik) WI/MB, MSc Traffic&Transport, (Vertiefungsmodul FB16, ggf. Auflage), Master Mechatronik, MSc. Informatik (Anwendungsfach Fahrzeugtechnik, Spezialisierung
8	**Grade bonus compliant to §25 (2)**
9	**References** Manuscript; e-Learning Materials via Moodle
Courses	

	Course nr. 16-27-5040-vl	**Course name** Automotive Mechatronics and Assistance Systems		
	Instructor		**Type** Lecture	**SWS** 3
	Course nr. 16-27-5040-ue	**Course name** Automotive Mechatronics and Assistance Systems		
	Instructor		**Type** Practice	**SWS** 2

Module name					
Tutorial Automotive Engineering					
Module nr. 16-27-5080	**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. Steven Peters		

1	**Teaching content** The Automotive Engineering Tutorium deepens special topics from the courses Motor Vehicles I+II on the basis of practically performed experiments. The selection of the experiments follows the availability of testing vehicles or current problems.
2	**Learning objectives** You are able to make independent experiments with vehicles for a given problem. This comprises the definition of test procedures and measuring devices. Test parameters are definied and varied. You are able to make use of the theoretical knowledge from Motor Vehicles I and II.
3	**Recommended prerequisites for participation** Fundamentals of automotive engineering
4	**Form of examination** Module exam: • Module exam (Technical examination, Special form, Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Special form, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References** materials are handed out to participants

Courses

Course nr.	Course name		
16-27-5080-tt	Tutorial Automotive Engineering		
Instructor		**Type** Tutorial	**SWS** 4

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** MSc ETiT, MSc WI-ETiT, MSc iST, MSc MEC, MSc MPE, MSc Physik
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture slides, Automotive Lighting and Human Vision, Handbuch Fahrassistenzsysteme

Courses

Course nr.	**Course name**	**Instructor**	**Type**	**SWS**
18-kh-2041-vl	Optical Technologies in Car Lighting	Prof. Dr.-Ing. Tran Quoc Khanh	Lecture	2
18-kh-2041-pr	Optische Technologien im KFZ-Bereich	Prof. Dr.-Ing. Tran Quoc Khanh	Internship	1

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** Dr.-Ing. Nicklas Norrick		

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					
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** MSc ETiT, MSc iST, MSc WI-ETiT, MSc MEC, MSc MPE, MSc Phys
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**
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**
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					
Combustion Engines II					
Module nr. 16-03-5020	**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. techn. Christian Beidl		

1 Teaching content

Electronic motor management: Configuration and structure, actuators and sensors, main functions, application, interfaces.
Ignition and combustion of hydrocarbons: Kinetic gas theory, internal combustion, correlation between in-cylinder pressure and heat release, efficiency, basics of the combustion (SI-engine / diesel-engine), abnormal combustion, combustion chamber shape and combustion processes.
Emissions: Components, corruptive effects, formation, influence of the operating point, internal motoric methods, aftertreatment, measuring systems, emission tests.
Charge cycle: Influence of the charge cycle on engine characteristics, systems, camshaft drivetrains, parameters of the charge cycle, variable valve timing, special solutions.
Charging: Characteristics and advantages of charging, different systems, design criterion for turbocharging, multi-stage charging, performed variants.
Noise: Basics, sources, measures against noise, regulations
Hybrid systems: Basics, functionalities, classification, components, challenges, research methods and certification, performed variants.
Acquisition and analysis of engine indication: Measurement chain, measurement of pressure and cylinder capacity, analysis, calculation of heat release, characteristic results
Design of experiments.

2 Learning objectives

On successful completion of this module, students should be able to:
1. Explain the different internal combustion engines and describe theoretically the processes.
2. Design combustion chambers with the knowledge acquired on the connection of combustion chamber shape, combustion processes, and ignition.
3. Define the emergence of emissions of engines (exhaust, noise) and describe the avoiding of emissions.
4. Describe the charge chaniging of a combustion engine, identify variants, and advance engines
5. Recognize the importance of charging and the variants.
6. Explain hybrid technology.
7. Reproduce specific measuring methods in the fields of optimizing engines (indication, design of experiments).

3 Recommended prerequisites for participation

4 Form of examination

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

Written (90 min) or oral exam (90 min, per group of 4 22,5 min per participiant).
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 %)

<table>
<tr><td>7</td><td colspan="4">Usability of the module
WPB Master MB II (Kernlehrveranstaltung aus dem Maschinenbau)
Master MB II SP CEPE
Master MB II SP FAS
Master Mechatronik</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
VKM II - script, available at the secretariat</td></tr>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
16-03-5020-vl</td><td colspan="3">Course name
Combustion Engines II</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Lecture</td><td>SWS
3</td></tr>
</table>

<table>
<tr><td colspan="6">Module name
Fundamentals of Navigation I</td></tr>
<tr><td>Module nr.
16-23-5050</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
English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Jürgen Beyer</td></tr>
</table>

1	**Teaching content** Navigation principles, Earth models, Coordinate systems, Radio navigation, Basics and instruments (ADF, VOR, DME, ILS), dead reckoning, functional principles and error analysis, satellite navigation, Introduction into GPS, signal description and measurement principles, Dilution of Precision (DoP), Differential GPS, Augmentation systems (RAIM, GIC, WAAS, LAAS, EGNOS).
2	**Learning objectives** On successful completion of this module, students should be able to: 1. Explain the physics associated with the navigation of the earth. 2. Classify common coordinate systems and map projections. 3. Judge the methods of radio, coupling, and satellite navigation with respect to performance and applications.
3	**Recommended prerequisites for participation** Recommanded: Control Engineering
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 20 Min., Default RS) Oral exam (in a group with 3 students) 60 min: 20 min per participiant
5	**Prerequisite for the award of credit points** Passing the examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** WPB Master MB III (Wahlfächer aus Natur- und Ingenieurwissenschaft) WPB Master AE III Nat_Ing-Bereich WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik) Master Mechatronik
8	**Grade bonus compliant to §25 (2)**
9	**References** Course notes available.

Courses

Course nr.	Course name	Instructor	Type	SWS
16-23-5050-vl	Fundamentals of Navigation I		Lecture	2
16-23-5050-ue	Fundamentals of Navigation I		Practice	1

Module name					
Space Debris - Risks, Surveillance and Mitigation					
Module nr. 16-23-3164	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Dr. Ing. Holger Krag		

1	**Teaching content** This lecture will provide the scientific, technical and operational background in relation to the sources, surveillance and mitigation of space debris. This covers risk assessment aspects: source and sink terms, particle flux models, aerodynamics and aerothermal aspects during atmospheric re-entry and related on-ground risk assessments; all major aspects of space surveillance: ground-based radar and telescope systems, orbit determination methods (batch least square, Levenberg-Marquardt, Kalmanfilter), residuals, covariances, operational collision avoidance; As well as space debris mitigation aspects: long-term environment projection models, international guidelines, passivation methods, shielding concepts, methods for post mission disposal and verification of measures;
2	**Learning objectives** On successful completion of this module, students should be able to: 1. name the sources of space debris and describe the human-made particle environment and the consequences of particle impacts; 2. analyse and determine the risks to a space mission due the natural and human-made particle environment and limit this this risk by suitable technical measures; 3. determine the on-ground risk caused by the atmospheric re-entry of a space object; 4. lay-out a space mission according to applicable space debris mitigation guidelines and verify the resulting setup along with international standards; 5. perform the main tasks of flight dynamics in operations (orbit determination and manoeuvre-planning) and explain the operational processes in the context of collision avoidance; 6. Present the main technical aspects of space surveillance, lay-out the required sensor systems and apply the related computational methods;
3	**Recommended prerequisites for participation** knowledge of the content of „Space Flight Mechanics" (module no. 16-25-5130) is an asset but not a pre-requisite.
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 examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** WPB Master MB III (Wahlfächer aus Natur- und Ingenieurwissenschaft) WPB Master AE III Nat_Ing-Bereich WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)
8	**Grade bonus compliant to §25 (2)**
9	**References** Klinkrad: Space Debris - Models and Risk Analysis, Springer Springer Praxis Books Astronautical Engineering, 2006, ISBN 978-3-540-37674-3

Courses				
	Course nr. 16-23-3164-vl	**Course name** Space Debris - Risks, Surveillance and Mitigation		
	Instructor		**Type** Lecture	**SWS** 2

Module name					
Tutorial Advanced Cax Methods					
Module nr. 16-07-5100	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr.-Ing. Dipl-Wirt.-Ing. Benjamin Schleich		

1	**Teaching content** Students gain knowledge of advanced CA Methods through the analysis of recent industrial examples. This course builds on the basic course 'Einführung in das rechnerunterstützte Konstruieren (CAD)'.
2	**Learning objectives** The students will be familiar with advanced CA Methods. They are able to recognise, execute and plan the generic workflow of CA Processes. Furthermore they are able to transfer their theoretical knowledge into industrial practice.
3	**Recommended prerequisites for participation** Einführung in das rechnergestützte Konstruieren (CAD) Virtuelle Produktentwicklung A, B, C
4	**Form of examination** Module exam: • Module exam (Technical examination, Special form, Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Special form, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
16-07-5100-tt	Tutorial Advanced CAx Methods		
Instructor		**Type** Tutorial	**SWS** 4

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** Msc etit, Msc MEC, Msc Wi-etit, Msc ICE, Msc CE, Msc Informatik
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

2.2 Optional Subjects AIS-IA: Intelligent Systems and Algorithms

Module name Introduction to Artificial Intelligence					
Module nr. 20-00-1058	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	**Teaching content** Artificial Intelligence (AI) is concerned with algorithms for solving problems, whose solution is generally assumed to require intelligence. While research in the early days was oriented on results about human thinking, the field has since developed towards solutions that try to exploit the strengths of the computer. In the course of this lecture we will give a brief survey over key topics of this core discipline of computer science, with a particular focus on the topics search, planning, learning, and reasoning. Historical and philosophical foundations will also be considered. • Foundations • Introduction, History of AI (RN chapter 1) • Intelligent Agents (RN chapter 2) • Search • Uninformed Search (RN chapters 3.1 - 3.4) • Heuristic Search (RN chapters 3.5, 3.6) • Local Search (RN chapter 4) • Constraint Satisfaction Problems (RN chapter 6) • Games: Adversarial Search (RN chapter 5) • Planning • Planning in State Space (RN chapter 10) • Planning in Plan Space (RN chapter 11) • Decisions under Uncertainty • Uncertainty and Probabilities (RN chapter 13) • Bayesian Networks (RN chapter 14) • Decision Making (RN chapter 16) • Machine Learning • Neural Networks (RN chapters 18.1,18.2,18.7) • Reinforcement Learning (RN chapter 21) • Philosophical Foundations
2	**Learning objectives** After a successful completion of this module, students are in a position to • understand and explain fundemental techniques of artificial intelligence • participate in a discussion about the possibility of an artificial intelligence with well-founded arguments • critically judge new developments in this area
3	**Recommended prerequisites for participation**
4	**Form of examination** Course related exam: • [20-00-1058-iv] (Technical examination, Oral/written examination, Default RS) Written Exam (90 min.)
5	**Prerequisite for the award of credit points** Pass exam (100%)

<table>
<tr><td>6</td><td colspan="4">Grading
Course related exam:
[20-00-1058-iv] (Technical examination, Oral/written examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td colspan="4">Usability of the module
B.Sc. Informatik
M.Sc. Informatik
M.Sc. Autonome Systeme und Robotik
M.Sc. Artificial Intelligence and Machine Learning

May be used in other degree programs.</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</td></tr>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
20-00-1058-iv</td><td colspan="3">Course name
Introduction to Artificial Intelligence</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. techn. Johannes Fürnkranz</td><td>Type
Integrated course</td><td>SWS
3</td></tr>
</table>

Module name					
Information Management					
Module nr.	**Credit points**	**Workload**	**Self-study**	**Module duration**	**Module cycle**
20-00-0015	5 CP	150 h	105 h	1 Term	Every 2. Semester
Language			**Module owner**		
German			Prof. Dr. phil. nat. Marc Fischlin		
1	**Teaching content**				

	Study Content Basic concepts of information management: Structured and unstructured data (text) as important data sources. Relevance of information management (operational information systems) Overview of data science and its subfields **Part 1: Structured data / databases** Data Modeling: Conceptual data models (ER / UML structure diagrams) Conceptual design Logical data model (relational model) Mapping from conceptual to logical model Relational query languages: SQL (in detail) Relational Algebra Database theory: Functional dependencies Design theory and normalization Implementation of database systems: Physical data storage Query processing and optimization Transaction processing Current trends in databases: Main-memory databases & Column-based data storage NoSQL databases Big Data Systems **Part 2: Unstructured Data / Text Processing** Basics of unstructured data: Storage and encoding of unstructured text Creating and annotating text corpora Lexical resources and knowledge bases Natural Language Processing: Segmentation Syntactic and semantic analysis Other Applications for unstructured data: Information Retrieval Information Extraction Advanced Topics: Introduction to research data management Data curation and visualization Documentation and archiving
2	**Learning objectives**

	After successful attendance of the course, students know the basics of information management and applications of information management (business information systems but also data science). They will understand the handling of structured and unstructured data and corresponding procedures and approaches for information processing. An outlook on further topics (e.g., research data management) and current trends in information management (e.g., Big Data) will be given.
3	**Recommended prerequisites for participation** Recommended: Participation of lecture „Funktionale und Objektorientierte Programmierkonzepte“ and „Algorithmen und Datenstrukturen“, respective according knowledge.
4	**Form of examination** Course related exam: • [20-00-0015-iv] (Technical examination, Oral/written examination, Default RS) Written exam (90 min.).
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0015-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B. Sc. Informatik B.Sc. Wirtschaftsinformatik Lehramt an Gymnasien - Fach 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 updated regularly; examples are: **Part1 :** Kemper, Alfons: "Datenbanksysteme: Eine Einführung" Haerder, Rahm, "Datenbanksysteme - Konzepte und Techniken der Implementierung" Hector Garcia-Molina: "Database Systems" **Part 2:** Jurafsky, Dan und Martin, James H.: “Speech and Language Processing”

Courses

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

Module name Efficient Graph Algorithms					
Module nr. 20-00-0110	**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. Heiko Mantel		

1	**Teaching content** - Efficient Data- Efficient Algorithms for Graph Scanning and Connectivity - Optimal Trees and Branchings - Network Flow Problems - Matching and Assignment - Planar Graphs. - Theory, Generic Approaches, Improvement by means of Speedup Techniques and Structures
2	**Learning objectives** After successfully attending the course, students - know fundamental algorithms - know techniques to improve efficiency - can analyse graph algorithms - know methods to exploit particular characteristics (planarity, sparseness) - can judge practical efficiency of techniques
3	**Recommended prerequisites for participation**
4	**Form of examination** Course related exam: • [20-00-0110-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0110-iv] (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)** 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 appointed in lecture

Courses

Course nr. 20-00-0110-iv	**Course name** Efficient Graph Algorithms		
Instructor		**Type** Integrated course	**SWS** 4

Module name					
Natural Language Processing and the Web					
Module nr. 20-00-0433	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	**Teaching content** The Web contains more than 10 billion indexable web pages, which can be retrieved via keyword search queries. The lecture will present natural language processing (NLP) methods to automatically process large amounts of unstructured text from the web and analyze the use of web data as a resource for other NLP tasks. Key topics: - Processing unstructured web content - NLP basics: tokenization, part-of-speech tagging, stemming, lemmatization, chunking - UIMA: principles and applications - Web contents and their characteristics, incl. diverse genres such as personal web sites, news sites, blogs, forums, wikis - The web as a corpus - innovative use of the web as a very large, distributed, interlinked, growing, and multilingual corpus - NLP applications for the web - Introduction to information retrieval - Web information retrieval and natural language interfaces - Web-based question answering - Mining Web 2.0 sites such as Wikipedia, Wiktionary - Quality assessment of web contents - Multilingualism - Internet of services: service retrieval - Sentiment analysis and community mining - Paraphrases, synonyms, semantic relatedness
2	**Learning objectives** After attending this course, students are in a position to - understand and differentiate between methods and approaches for processing unstructured text, - reconstruct and explicate the principle of operation of web search engines, - construct and analyze exemplary NLP applications for web data, - analyze and evaluate the potential of using web contents to enhance NLP applications.
3	**Recommended prerequisites for participation** Basic knowledge in Algorithms and Data Structure Programming in Java
4	**Form of examination** Course related exam: • [20-00-0433-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0433-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 Can 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** - Kai-Uwe Carstensen, Christian Ebert, Cornelia Endriss, Susanne Jekat, Ralf Klabunde: Computerlinguistik und Sprachtechnologie. Eine Einführung. 3. Auflage. Heidelberg: Spektrum, 2009. ISBN: 978-3-8274-20123-7. - http://www.linguistics.rub.de/CLBuch/ - T. Götz, O. Suhre: Design and implementation of the UIMA Common Analysis System, IBM Systems Journal 43(3): 476-489, 2004. - Adam Kilgarriff, Gregory Grefenstette: Introduction to the Special Issue on the Web as Corpus, Computational Linguistics 29(3): 333-347, 2003. - Christopher D. Manning, Prabhakar Raghavan, Hinrich Schütze: Introduction to Information Retrieval, Cambridge: Cambridge University Press, 2008. ISBN: 978-0-521-86571-5. http://nlp.stanford.edu/IR-book/

Courses

Course nr.	Course name		
20-00-0433-iv	Natural Language Processing and the Web		
Instructor		**Type** Integrated course	**SWS** 4

Module name					
Data Mining and Machine Learning					
Module nr. 20-00-0052	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Teaching content

With the rapid development of information technology bigger and bigger amounts of data are available. These often contain implicit knowledge, which, if it were known, could have significant commercial or scientific value. Data Mining is a research area that is concerned with the search for potentially useful knowledge in large data sets, and machine learning is one of the key techniques in this area.

This course offers an introduction into the area of machine learning from the angle of data mining. Different techniques from various paradigms of machine learning will be introduced with exemplary applications. To operationalize this knowledge, a practical part of the course is concerned with the use of data mining tools in applications.

- Introduction (Foundation, Learning problems, Concepts, Examples, Representation)
- Rule Learning
  - Learning of indivicual rules (generalization vs. specialization, structured hypothesis spaces, version spaces)
  - Learning of rule sets (covering strategy, evaluation measures for rules, pruning, multi-class problems)
- Evaluation and cost-sensitive Learning (Accuracy, X-Val, ROC Curves, Cost-Sensitive Learning)
- Instance-Based Learning (kNN, IBL, NEAR, RISE)
- Decision Tree Learning (ID3, C4.5, etc.)
- Ensemble Methods (Bias/Variance, Bagging, Randomization, Boosting, Stacking, ECOCs)
- Pre-Processing (Feature Subset Selection, Discretization, Sampling, Data Cleaning)
- Clustering and Learning of Association Rules (Apriori)"

2 Learning objectives

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

3 Recommended prerequisites for participation

4 Form of examination

Course related exam:
- [20-00-0052-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:
- [20-00-0052-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

	B. Sc. Informatik M. Sc. Informatik M. Sc. Computer Science M. Sc. Autonome Systeme und Robotik M. Sc. Artificial Intelligence and Machine Learning M. Sc. IT Sicherheit May be used in other degree programs.
8	**Grade bonus compliant to §25 (2)** In this course a crediting of lecture-accompanying achievements takes place, which can lead to a grade improvement of up to 1.0 according to 25(2) of the 6th amendment of the General Examination Regulations of the TU Darmstadt and the crediting rules decided by the Department of Computer Science on July 14, 2022.
9	**References** - Mitchell: Machine Learning, McGraw-Hill, 1997 - Ian H. Witten and Eibe Frank: Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations, Morgan-Kaufmann, 1999

Courses

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

Module name Deep Learning for Natural Language Processing					
Module nr. 20-00-0947	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. phil. Iryna Gurevych		

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

Courses

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

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** BSc iST, MSc ETiT, MSc MEC, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik
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.	Course name		
	18-ad-2020-ue	Fuzzy Logic, Neuronal Networks and Evolutionary Algorithms		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Jürgen Adamy		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**
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

<table>
<tr><td colspan="6">Module name
Introduction to Scientific Computing with Python</td></tr>
<tr><td>Module nr.
18-st-2070</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
Summer term</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

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

Etit B.A./M.Sc. with all options, as well as CE, ICE, IST

8 Grade bonus compliant to §25 (2)

9 References

Courses

	Course nr.	Course name		
	18-st-2070-pr	Introduction to Scientific Computing with Python		
	Instructor		**Type**	**SWS**
	Prof. Dr. techn. Heinz Köppl, Prof. Dr. rer. nat. Florian Steinke, Prof. Dr.-Ing. Herbert De Gersem, Prof. Dr. rer. nat. Markus Meinert, Prof. Dr. rer. nat. Sebastian Schöps		Internship	2

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** MSc WI-etit, MSc iST, MSc iCE
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					
Web-Mining					
Module nr. 20-00-0101	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	Teaching content

The World-Wide Web provides every internet uses access to an ever-growing plentitude of information, which can not be processed without appropriate support. Web Mining is the research area that is tries to solve this problem with machine learning and data mining techniques. In this course, we will discuss foundations of information retrieval and text classification, as well as consider the pecularities of web documents (i.e. their document and graph structure).

- Introduction
- Web Mining Overview
- The Web, HTTP, HTML, DOM, XPath
- Data Mining Overview
- Structured, Semi-Structured and Unstructured Data
- Sample Web Mining Tasks
- Information Retrieval on the Web
- search engines & web crawlers
- document indexing
- the vector space model
- inverted index
- performance measures (recall & precision)
- relevance feedback
- estimating the size of the web
- Text Mining
- text classification
- document representation
- induction of classifiers (k-NN, Naive Bayes, SVMs, Rule Learners)
- Overfitting Avoidance
- Evaluation of Classifiers
- Multi-Label Classification
- feature engineering
- stop words
- feature subset selection
- n-grams
- stemming
- phrases
- latent semantic indexing
- semi- and unsupervised learning
- clustering (k-means, bottom-up agglomerative)
- semi-supervised learning (active learning, self-training, co-training)
- Structure mining
- the Web as a graph
- hyperlink-based relevance ranking (hubs and authorities, page rank)
- hypertext classification (Naive Method, HyperClass, hyperlink ensembles)
- Information Extraction & Wrapper Induction
- conventional information extraction (AutoSlog)
- structured text (LR-Wrappers)
- semi-structured text (SoftMealy, WHISK, SRV, RAPIER)
- Web Usage Mining
- recommender systems
- memory-based collaborative filtering
- model-based collaborative filtering
- web log mining

2 Learning objectives

	After attending this course, students are in a position to - understand and explain fundemental techniques of information retrieval and web mining - apply practical information retrieval and web mining systems and understand their strengths and limitations - critically judge new developments in this area
3	**Recommended prerequisites for participation**
4	**Form of examination** Course related exam: • [20-00-0101-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0101-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** - Soumen Chakrabarti: Mining the Web - Discovering Knowledge from Hypertext Data. Morgan Kaufmann Publishers, 2003. - Christopher D. Manning, P. Raghavan and H. Schütze, Introduction to Information Retrieval, Cambridge University Press. 2008.

Courses

Course nr.	Course name		
20-00-0101-iv	Web Mining		
Instructor		**Type**	**SWS**
		Integrated course	4

Module name Practical Lab Algorithms					
Module nr. 20-00-0189	**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. Heiko Mantel		

1	**Teaching content** Solution of an algorithmic problem form practice and its implementation in software.
2	**Learning objectives** In this course students acquire expertise in solving algorithmic problems from practice and skill to implement efficient algorithms
3	**Recommended prerequisites for participation** - Knowledge in program language (e.g. Java / C++) - Knowledge about basic algorithms and data structure
4	**Form of examination** Course related exam: • [20-00-0189-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0189-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** Will be given in lecture.

Courses

Course nr.	Course name		
20-00-0189-pr	Practical Lab Algorithms		
Instructor		**Type** Internship	**SWS** 4

Module name Practical Course in Artificial Intelligence					
Module nr. 20-00-0412	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	**Teaching content** Students have to work on a concrete practical problem in the area of artificial intelligence and solve it with the help of tools and techniques that they developed on their own or that are already publicly available. Note the announcements on the homepage of the KE group regarding this course (http://www.ke.informatik.tu-darmstadt.de/lehre/)! In semesters, where this course is not announced on the above pages, there is often the possibility of individual projects (please ask).
2	**Learning objectives** After completion of this practical course, students should be able to - recognize potential uses of artificial intelligence tools - select appropriate tools for a given task and apply them to this task - evaluate and measure the success of the use of such tools
3	**Recommended prerequisites for participation** Basic knowledge in artificial intelligence
4	**Form of examination** Course related exam: • [20-00-0412-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0412-pr] (Study achievement, 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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References**
Courses	

<table>
<tr><td rowspan="2"></td><td>Course nr.
20-00-0412-pr</td><td colspan="3">Course name
Practical Course in Artificial Intelligence</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Internship</td><td>SWS
4</td></tr>
</table>

Module name Seminar Data Mining and Machine Learning					
Module nr. 20-00-0102	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	**Teaching content** This seminar serves the purpose of discussing new research papers in the areas of data mining and machine learning. Every participant will present one paper, which will be subsequently discussed by all participants. Grades are based on the preparation and presentation of the paper, as well as the participation in the discussion, in some cases also a written report. The papers will typically recent publications in relevant journals such as “Data Mining and Knowledge Discovery”, ""Machine Learning"", as well as ""Journal of Machine Learning Research"". Students may also propose their own topics if they fit the theme of the seminar. Please note current announcements to this course at http://www.ke.informatik.tu-darmstadt.de/lehre.
2	**Learning objectives** After this seminar, students should be able to - understand an unknown text in the area of machine learning - work out a presentation for an audience proficient in this field - make useful contributions in a scientific discussion in the area of machine learning
3	**Recommended prerequisites for participation** Basic knowledge in Machine Learning and Data Mining
4	**Form of examination** Course related exam: • [20-00-0102-se] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0102-se] (Study achievement, 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)**
9	**References**
Courses	

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

Module name					
Statistical Machine Learning					
Module nr. 20-00-0358	**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. Kristian Kersting		

1 Teaching content

- Statistical Methods for Machine Learning
- Refreshers on Statistics, Optimization and Linear Algebra
- Bayes Decision Theory
- Probability Density Estimation
- Non-Parametric Models
- Mixture Models and EM-Algorithms
- Linear Models for Classification and Regression
- Statistical Learning Theory
- Kernel Methods for Classification and Regression

2 Learning objectives

The lecture gives a systematic introduction to statistical methods for machine learning. Upon successful completion of this lecture, students will understand the most important methods and approaches of statistical machine learning. They can apply machine learning to solve various new problems.

3 Recommended prerequisites for participation

4 Form of examination

Course related exam:

- [20-00-0358-iv] (Technical examination, Oral/written examination, Default RS)

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:

- [20-00-0358-iv] (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

Can 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

1. C.M. Bishop, Pattern Recognition and Machine Learning (2006), Springer
2. K.P. Murphy, Machine Learning: a Probabilistic Perspective (expected 2012), MIT Press
3. D. Barber, Bayesian Reasoning and Machine Learning (2012), Cambridge University Press
4. T. Hastie, R. Tibshirani, and J. Friedman (2003), The Elements of Statistical Learning, Springer Verlag
5. D. MacKay, Information Theory, Inference, and Learning Algorithms (2003), Cambridge University Press
6. R.O. Duda, P.E. Hart, and D.G. Stork, Pattern Classification (2nd ed. 2001), Willey-Interscience
7. T.M. Mitchell, Machine Learning (1997), McGraw-Hill

Courses

Course nr.	**Course name**
20-00-0358-iv	Statistical Machine Learning

Instructor	**Type**	**SWS**
Prof. Dr. rer. nat. Kristian Kersting	Integrated course	4

Module name Project Lab Deep Learning in Computer Vision					
Module nr. 20-00-0980	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1	**Teaching content** In this project lab groups of students will work on selected topics in deep learning (deep neural networks) for problems in computer vision. This includes the practical implementation with modern deep learning frameworks. Results will be presented in a talk at the end of the lab. Concrete topics follow the current state of the art and change from term to term.
2	**Learning objectives** Through their successful participation, students acquire in-depth knowledge on deep neural networks and their applications in computer vision. They are able to analyze, modify, and apply state-of-the-art techniques in this area. Moreover, they practice their abilities for presenting their results and for collaboration in teams.
3	**Recommended prerequisites for participation** * Solid programming skills in C/C++ or Python or Lua * Prior or concurrent registration for "Computer Vision I"
4	**Form of examination** Course related exam: • [20-00-0980-pp] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0980-pp] (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		
20-00-0980-pp	Project Lab Deep Learning in Computer Vision		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Michael Gösele		Internship	6

Module name Learning and Educational Technologies					
Module nr. 20-00-0773	**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. rer. nat. Eberhard Mühlhäuser		

1	**Teaching content** Digital applications and the Internet are changing the way we learn. If digital teaching and learning applications are designed appropriately, they offer a wide range of possibilities. The module aims to impart basic knowledge about the most important aspects of system design and about technologies needed for modern, web-based and mobile learning applications. Important theoretical foundations for the design of learning applications are learning theories. Therefore, learning theories are briefly discussed in the context of this module. The focus of the module is on adaptive learning applications. Different methods for the realization of adaptive learning applications will be presented. Frequently, Natural Language Processing and Artificial Intelligence methods are used for this purpose. In this context, current research work is considered. The module also focuses on the design of learning applications for individual and cooperative learning in various fields of application (e.g. school, university, vocational education and lifelong learning). Examples from current research projects as well as teaching/learning practice are presented. In addition, methods for the evaluation of learning applications are considered.
2	**Learning objectives** After completion of the module, students will be able to analyze and design applications for knowledge acquisition and learning based on different design patterns and technologies. They will be able to decide on information representation (data level), design of functionalities (application level), and selection/configuration of algorithms to support platform users concerning challenges in the learning process. Students are capable to consider techniques of adaptation to learners needs and will know appropriate evaluation methods to measure the qualities and effects of learning applications and the algorithms and methods used in the learning applications.
3	**Recommended prerequisites for participation** Basic knowledge of Machine Learning and Natural Language Processing is desirable but not a prerequisite. For students who do not meet these requirements, we offer short learning modules that allow an understanding of the application-specific mechanisms.
4	**Form of examination** Course related exam: • [20-00-0773-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0773-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. Informatik M.Sc. Informatik Kann in anderen Studiengängen verwendet werden.
8	**Grade bonus compliant to §25 (2)**
9	**References**
Courses	

	Course nr.	Course name		
	20-00-0773-iv	Learning and Educational Technologies		
	Instructor		**Type**	**SWS**
	Prof. Dr. rer. nat. Eberhard Mühlhäuser		Integrated course	4

<table>
<tr><td colspan="7">Module name
Algorithmic Modelling</td></tr>
<tr><td>Module nr.
20-00-0113</td><td colspan="2">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="4">Language
German</td><td colspan="3">Module owner
Prof. Dr.-Ing. Heiko Mantel</td></tr>
<tr><td>1</td><td colspan="6">Teaching content
- Algorithmic modeling languages like OPL and eclipse
- modeling problems as (integer) linear programming problems
- modelling as combinatorial optimization problems
- complex case studies: e.g. applications in logistics and manufacturing; deterministic and stochastic scheduling</td></tr>
<tr><td>2</td><td colspan="6">Learning objectives
After successfully attending the course,
- students know modelling strategies for decision, construction, and optimization problems
- students can apply two algorithmic modelling languages
- student can adequately model complex problems</td></tr>
<tr><td>3</td><td colspan="6">Recommended prerequisites for participation
Grundzüge III der Informatik oder vergleichbar (Einführung in Foundations of Computing wäre ebenfalls wünschenswert).</td></tr>
<tr><td>4</td><td colspan="6">Form of examination
Course related exam:
• [20-00-0113-iv] (Technical examination, Oral/written examination, Default RS)</td></tr>
<tr><td>5</td><td colspan="6">Prerequisite for the award of credit points
Pass Exam (100%)</td></tr>
<tr><td>6</td><td colspan="6">Grading
Course related exam:
• [20-00-0113-iv] (Technical examination, Oral/written examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td colspan="6">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.</td></tr>
<tr><td>8</td><td colspan="6">Grade bonus compliant to §25 (2)
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<tr><td>9</td><td colspan="6">References
Will be appointed in lecture.</td></tr>
<tr><td colspan="7">Courses</td></tr>
</table>

	Course nr.	Course name		
	20-00-0113-iv	Algorithmic Modelling		
	Instructor		**Type** Integrated course	**SWS** 4

Module name Practical Lab Advanced Algorithms					
Module nr. 20-00-0276	**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. Heiko Mantel		

1	**Teaching content** Solution of an advanced algorithmic problem form practice and its implementation in software.
2	**Learning objectives** In this course students enhance their expertise in solving algorithmic problems from practice and their skills to implement efficient algorithms
3	**Recommended prerequisites for participation** Based on Lab Algorithms
4	**Form of examination** Course related exam: • [20-00-0276-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0276-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** Will be given in lab.

Courses

Course nr.	Course name		
20-00-0276-pr	Advanced Algorithms		
Instructor		**Type** Internship	**SWS** 4

Module name					
Concepts and Technologies for Distributed Systems and Big Data Processing					
Module nr. 20-00-0951	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Dr.-Ing. Michael Eichberg		

1	**Teaching content** The course provides an overview of recent advances in distributed systems for Big Data processing. The course starts presenting computational models for high throughput batch processing like MapReduce. Next, we will introduce software engineering techniques for distributed systems such as REST and component-based architectures. We will then cover low latency real time stream processing and complex event processing. Finally, we will present advanced topics in distributed data-intensive systems, such as geodistribution and security. The course focuses both on the fundamental concepts as well as on the concrete technologies and applications of the aforementioned techniques to real-world case studies.
2	**Learning objectives** - The students are familiar with basic concepts and technologies on distributed systems and big data and are able to implement basic cloud based/distributed applications. - The students are familiar with the fundamental computational models behind recent advances in distributed systems, such as models for batch processing of massive data amounts, stream processing and complex event processing. - The students are familiar with selected advanced topics on big data, including security and geolocalization. - The students know about real-world case studies that apply the concepts and the technologies presented during the course.
3	**Recommended prerequisites for participation** This course is targeted at master students.
4	**Form of examination** Course related exam: • [20-00-0951-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0951-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**

9	**References**

Courses

Course nr.	Course name		
20-00-0951-iv	Concepts and Technologies for Distributed Systems and Big Data Processing		
Instructor		**Type**	**SWS**
Dr.-Ing. Michael Eichberg		Integrated course	2

Module name Foundations of Language Technology					
Module nr. 20-00-0546	**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. techn. Johannes Fürnkranz		

1	**Teaching content** This lecture provides an introduction into the fundamental perspectives, problems, methods, and techniques of text technology and natural language processing using the example of the Python programming language. Key topics: - Natural language processing (NLP) - Tokenization - Segmentation - Part-of-speech tagging - Corpora - Statistical analysis - Machine Learning - Categorization and classification - Information extraction - Introduction to Python - Data structures - Structured programming - Working with files - Usage of libraries - NLTK library The course is based on the Python programming language together with an open-source library called the Natural Language Toolkit (NLTK). NLTK allows explorative and problem-solving learning of theoretical concepts without the requirement of extensive programming knowledge.
2	**Learning objectives** After attending this course, students are in a position to - define the fundamental terminology of the language technology field, - specify and explain the central questions and challenges of this field, - explicate and implement simple Python programs, - transfer the learned techniques and methods to practical application scenarios of text understanding, as well as - critically assess their merits and limitations.
3	**Recommended prerequisites for participation**
4	**Form of examination** Course related exam: • [20-00-0546-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0546-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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References** Steven Bird, Ewan Klein, Edward Loper: Natural Language Processing with Python, O'Reilly, 2009. ISBN: 978-0596516499. http://www.nltk.org/book/

Courses

Course nr.	Course name		
20-00-0546-iv	Foundations of Language Technology		
Instructor		**Type**	**SWS**
Prof. Dr. phil. Iryna Gurevych		Integrated course	4

Module name Bioinformatics					
Module nr. 10-30-0036	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner**		

1	**Teaching content**
2	**Learning objectives**
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, 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**

Courses

Course nr.	**Course name**	**Instructor**	**Type**	**SWS**
10-01-0036-vl	Bio Informatics-Lecture		Lecture	2
10-01-0036-se	Bio Informatics-Exercise		Practice	2

Module name					
Optimization Algorithms					
Module nr. 20-00-0667	**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. rer. nat. Karsten Weihe		

1 Teaching content

Algorithmic standard approaches to complex discrete optimization problems; for example, evolution strategies, dynamic programming, branch-and-bound, etc.

2 Learning objectives

In this course students acquire systematic knowledge of generic algorithmic approaches in discrete optimization and the abitiliy to tackle complex discrete optimization problems algorithmically.

3 Recommended prerequisites for participation

Funktionale und objektorientierte Programmierkonzepte, Algorithmen und Datenstrukturen or similar.

4 Form of examination

Course related exam:

- [20-00-0667-iv] (Technical examination, Oral/written examination, Default RS)

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:

- [20-00-0667-iv] (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

Can be used in other degree programs.

8 Grade bonus compliant to §25 (2)

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9 References

Will be given in lecture.

Courses

Course nr.	Course name		
20-00-0667-iv	Optimization Algorithms		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Karsten Weihe		Integrated course	4

Module name					
Ambient Intelligence					
Module nr. 20-00-0390	**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. Bernt Schiele		

1	**Teaching content** The course will provide an overview of a new vision for Human-Computer-Interaction (HCI) in which people are surrounded by intelligent and intuitive interfaces embedded in the everyday objects around them. In specific the course addresses the emergence of Ambient Mobility and the ubiquitous, pervasive information access, retrieval and display on mobile devices. It will focus on understanding enabling technologies and studying applications and experiments, and, to lesser extent, it will adress the sociocultural impact. Additional topics of the lecture include system architectures for distributed systems, context awareness and management, user models and their implications, sensing and interaction in smart environments. The lecture discusses recent topics and research projects in the domain of Ambient Intelligence.
2	**Learning objectives** After successfully attending the lecture, the students will be able to describe technology trends and research results in the domain of Ambient Intelligence. The most important concepts to create smart environments - intelligent networks and objects, technologies for mobile, augmented reality, ubiquitous and pervasive information spaces, nomadic communications, real-time communication and related middle ware, embedded systems, sensor networks and wearable computing - can be discussed and classified. After completing the practical part, students will be able to plan and realize the different project phases required to develop an Ambient-Intelligence solution.
3	**Recommended prerequisites for participation** Master-Students Participation in lecture “Visual Computing“ and „Multimodale Interaktion mit intelligenten Umgebungen“
4	**Form of examination** Course related exam: • [20-00-0390-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0390-iv] (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 Can 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** Will be given according to actual topics.

Courses

Course nr.	Course name		
20-00-0390-iv	Ambient Intelligence		
Instructor		**Type**	**SWS**
		Integrated course	4

Module name					
Automata, Formal Languages and Decidability					
Module nr. 04-10-0120/de	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. rer. nat. Martin Otto		

1	**Teaching content** introduction: transition systems, words, languages; basic mathematical methods and proof patterns; finite automata and regular languages; determinism and nondeterminism, closure properties and automata constructions, Kleene Theorem, Myhill-Nerode Theorem, pumping lemma; grammars and the Chomsky hierrachy, context-free languages, pumping lemma, CYK algorithm; models of computation: PDA and Turing machines; decidability and recursive enumerability in the Chomsky hierarchy
2	**Learning objectives** Schöning: Theoretische Informatik – kurz gefasst \newline Hopcroft, Motwani, Ullman: Einführung in die Automatentheorie, formale Sprachen und Komplexitätstheorie \newline Wegener: Theoretische Informatik – eine algorithmenorientierte Einführung \newline Skript (elektronisch unter www.mathematik.tu-darmstadt.de/~otto)
3	**Recommended prerequisites for participation** none
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, p/np RS) • Module exam (Technical examination, Oral/written examination, Default RS) Fachprüfung: 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. Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first 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: 0 %) • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References**
Courses	

<table>
<tr><td rowspan="2"></td><td>Course nr.
04-00-0091-vu</td><td colspan="3">Course name
Automata, Formal Languages and Decidability</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. rer. nat. Martin Otto</td><td>Type
Lecture and practice</td><td>SWS
3</td></tr>
</table>

Module name Propositional Logic and Predicate Logic					
Module nr. 04-10-0121/de	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. rer. nat. Martin Otto		

1	**Teaching content** syntax and semantics of propositional logic, functional completeness and normal forms, compactness, complete proof calculi: resolution and a sequent calculus; \newline syntax and semantics of first-order logic, structures and assignments, normal forms, Skolemization, Herbrand theorem, compactness, complete proof calculi: (ground) resolution and a sequent calculus, Gödel's Completeness Theorem; undecidability of first-order logic; \newline optional: digressions on expressiveness and model checking
2	**Learning objectives**
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, p/np RS) • Module exam (Technical examination, Oral/written examination, Default RS) Fachprüfung: 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. Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first 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: 0 %) • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References**

	Burris: Logic for Mathematics and Computer Science \newline Schöning: Logik für Informatiker \newline Boolos, Burgess, Jeffrey: Computability and Logic \newline Skript (2 Teile, elektronisch unter www.mathematik.tu-darmstadt.de/~otto)

Courses

Course nr.	Course name		
04-00-0090-vu	Propositional Logic and Predicate Logic		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Martin Otto		Lecture and practice	3

Module name Deep Learning: Architectures & Methods					
Module nr. 20-00-1034	**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. techn. Johannes Fürnkranz		

1	**Teaching content** • Review of machine learning background • Deep Feedforward Networks • Regularization for Deep Learning • Optimization for Training Deep Models • Convolutional Networks • Sequence Modeling: Recurrent and Recursive Nets • Linear Factor Models • Autoencoders • Representation Learning • Structured Probabilistic Models for Deep Learning • Monte Carlo Methods • Approximate Inference • Deep Generative Models • Deep Reinforcement Learning • Deep Learning in Vision • Deep Learning in NLP
2	**Learning objectives** This course provides students with the required advanced background on machine learning the knowledge to independently carry out research projects on the hot topic of deep learning, e.g. within the scope of a Bachelor's or Master's thesis. In particular, this class aims at providing the students with fundamental understanding of deep learning algorithms and the architecture of deep networks.
3	**Recommended prerequisites for participation** 20-00-0358-iv Statistical Machine Learning 20-00-0052-iv Data Mining and Machine Learning
4	**Form of examination** Course related exam: • [20-00-1034-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1034-iv] (Technical examination, 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)** 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**		
Courses			
	Course nr. 20-00-1034-iv	**Course name** Deep Learning: Architectures & Methods	
	Instructor Prof. Dr. techn. Johannes Fürnkranz	**Type** Integrated course	**SWS** 4

Module name					
Reinforcement Learning: From Foundations to Deep Approaches					
Module nr. 20-00-1047	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1	**Teaching content** • Review of machine learning background • Black box Reinforcement Learning • Modeling as bandit, Markov Decision Processes and Partially Observable Markov Decision Processes • Optimal control • System identification • Learning value functions • Policy search • Deep value functions methods • Deep policy search methods • Exploration vs exploitation • Hierarchical reinforcement learning • Intrinsic motivation
2	**Learning objectives** This course provides students with the required basic background on machine learning the knowledge to independently carry out research projects on the hot topic of reinforcement learning, e.g. within the scope of a Bachelor's or Master's thesis. In particular, this class aims at providing the students with fundamental understanding of reinforcement learning algorithms and the application within deep learning.
3	**Recommended prerequisites for participation** Good programming in Python. Lecture Statistical Machine Learning is helpful but not mandatory.
4	**Form of examination** Course related exam: • [20-00-1047-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1047-iv] (Technical examination, 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**
Courses	

	Course nr.	Course name		
	20-00-1047-iv	Reinforcement Learning: From Foundations to Deep Approaches		
	Instructor		**Type**	**SWS**
	Prof. Dr. rer. nat. Oskar von Stryk		Integrated course	4

Module name Text Analytics					
Module nr. 20-00-0596	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. phil. Iryna Gurevych		

1	**Teaching content** The seminar introduces current topics in natural language processing. It provides a thorough introduction into state-of-the-art technology in text analytics. The main focus of the seminar changes each semester. Further information: https://www.ukp.tu-darmstadt.de/teaching/courses/regular-seminar/
2	**Learning objectives** After attending this course, students are in a position to - name and explain state-of-the-art research questions in the area of the seminar, - understand, critically assess, and discuss scientific publications, - independently comprehend and work out a research topic and - present it to the group and react on questions and discussion threads.
3	**Recommended prerequisites for participation**
4	**Form of examination** Course related exam: • [20-00-0596-se] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0596-se] (Study achievement, 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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be given in seminar.

Courses

Course nr.	Course name		
20-00-0596-se	Text Analytics		
Instructor		**Type**	**SWS**
Prof. Dr. phil. Iryna Gurevych		Seminar	2

Module name					
Extended Seminar - Systems and Machine Learning					
Module nr. 20-00-1057	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	**Teaching content** This seminar serves the purpose of discussing new research papers in the intersection of hardware/software-systems and machine learning. The seminar aims to elicit new connections amongst these fields and discusses important topics regarding systems questions machine learning including topics such as hardware accelerators for ML, distributed scalable ML systems, novel programming paradigms for ML, Automated ML approaches, as well as using ML for systems. Every participant will present one research paper, which will be subsequently discussed by all participants. In addition, summary papers will be written in groups and submitted to a peer review process. The papers will typically be recent publications in relevant research venues and journals. The seminar will be offered as a block seminar. Further information can be found at: http://binnig.name
2	**Learning objectives** After this seminar, the students should be able to - understand a new research contribution in the areas of the seminar - prepare a written report and present the results of such a paper in front of an audience - participate in a discussion in the areas of the seminar - to peer-review the results of other students
3	**Recommended prerequisites for participation** Basic knowledge in Machine Learning, Data Management, and Hardware-/Software-Systems.
4	**Form of examination** Course related exam: • [20-00-1057-se] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1057-se] (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**
Courses	

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

Module name Algorithmic modeling for creating schedules						
Module nr. 20-00-0391		**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German				**Module owner** Prof. Dr.-Ing. Heiko Mantel		
1	**Teaching content** - Modeling of periodic schedules especially for railways - Respecting infrastructural constrains in schedule creation - robustness of schedules - timetable information systems					
2	**Learning objectives** After successfully attending the course, students have gained skills in algorithmic modelling in the field of railway optimization					
3	**Recommended prerequisites for participation** Algorithms and data structure					
4	**Form of examination** Course related exam: • [20-00-0391-se] (Study achievement, Oral/written examination, Default RS)					
5	**Prerequisite for the award of credit points** Pass exam (100%)					
6	**Grading** Course related exam: • [20-00-0391-se] (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 Can be used in other degree programs.					
8	**Grade bonus compliant to §25 (2)**					
9	**References** Will be given in seminar.					
Courses						

<table>
<tr><td rowspan="2"></td><td>Course nr.
20-00-0391-se</td><td colspan="3">Course name
Algorithmic modelling for creating schedules</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Seminar</td><td>SWS
2</td></tr>
</table>

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**
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					
Deep Generative Models					
Module nr. 20-00-1035	**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.-Ing. Michael Gösele		

1	**Teaching content** Generative Models, Implicit and Explicit Models, Maximum Likelihood, Variational AutoEncoders, Generative Adversarial networks, Numerical Optimization for Generative models, Applications in medical Imaging
2	**Learning objectives** After students have attended the module, they can - Explain the structure and operation of Deep Generative Models (DGM) - Critically scrutinize scientific publications on the topic of DGMs and thus assess them professionally - independently construct / implement basic DTMs in a high-level programming language designed for this purpose - Transfer the implementation and application of DTMs to different applications
3	**Recommended prerequisites for participation** - Python Programming - Linear Algebra - Image Processing/Computer Vision I - Statistical Machine Learning
4	**Form of examination** Course related exam: • [20-00-1035-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1035-iv] (Technical examination, 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)** 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** No textbooks as such. Online materials will be made available during the course.

Courses

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

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** MSc (Wi-) etit, BSc/MSc iST, MSc iCE, MSc MEC
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.-Ing. Andrea Jimenez, Dr. rer. nat. Sabrina Klos	Lecture	2
18-kl-2070-ue	Fundamentals of Reinforcement Learning	Dr. rer. nat. Sabrina Klos	Practice	1

Module name					
Introduction to Artificial Intelligence					
Module nr. 20-00-1058	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	**Teaching content** Artificial Intelligence (AI) is concerned with algorithms for solving problems, whose solution is generally assumed to require intelligence. While research in the early days was oriented on results about human thinking, the field has since developed towards solutions that try to exploit the strengths of the computer. In the course of this lecture we will give a brief survey over key topics of this core discipline of computer science, with a particular focus on the topics search, planning, learning, and reasoning. Historical and philosophical foundations will also be considered. • Foundations • Introduction, History of AI (RN chapter 1) • Intelligent Agents (RN chapter 2) • Search • Uninformed Search (RN chapters 3.1 - 3.4) • Heuristic Search (RN chapters 3.5, 3.6) • Local Search (RN chapter 4) • Constraint Satisfaction Problems (RN chapter 6) • Games: Adversarial Search (RN chapter 5) • Planning • Planning in State Space (RN chapter 10) • Planning in Plan Space (RN chapter 11) • Decisions under Uncertainty • Uncertainty and Probabilities (RN chapter 13) • Bayesian Networks (RN chapter 14) • Decision Making (RN chapter 16) • Machine Learning • Neural Networks (RN chapters 18.1,18.2,18.7) • Reinforcement Learning (RN chapter 21) • Philosophical Foundations
2	**Learning objectives** After a successful completion of this module, students are in a position to • understand and explain fundemental techniques of artificial intelligence • participate in a discussion about the possibility of an artificial intelligence with well-founded arguments • critically judge new developments in this area
3	**Recommended prerequisites for participation**
4	**Form of examination** Course related exam: • [20-00-1058-iv] (Technical examination, Oral/written examination, Default RS) Written Exam (90 min.)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading**

	Course related exam: • [20-00-1058-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. Informatik M.Sc. Informatik M.Sc. Autonome Systeme und Robotik M.Sc. Artificial Intelligence and Machine Learning May be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name	Instructor	Type	SWS
20-00-1058-iv	Introduction to Artificial Intelligence	Prof. Dr. techn. Johannes Fürnkranz	Integrated course	3

Module name Introduction to Quantum Computing					
Module nr. 20-00-1136	**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.-Ing. Ermira Mezini		

1	**Teaching content** General introduction and motivation Introduction to Quantum mechanics (states, measurements, evolution, a short review of linear algebra) Elementary quantum gates and circuit model Universal quantum computation Quantum parallelism and Deutsch-Jozsa Algorithm Simon's Algorithm The Fourier Transform Shor's Factoring Algorithm Hidden Subgroup Problem Grover's Search Algorithm Quantum Error-Correction and Fault-Tolerance Entanglement and Nonlocality A basic introduction to quantum key distribution Overview of quantum computing platforms and claims of quantum advantage
2	**Learning objectives** After completing the module, students will be familiar with all of the fundamental concepts of quantum information processing and computing and will be able to program them using the quantum programming language Qiskit. They will learn the most important ‘peculiarities' of the quantum world and will be able to connect them to computational and cryptographic tasks. Finally, at the end of the lecture, a summary of the most recent developments in industry and academia will be provided, allowing students to navigate their future interests in the field
3	**Recommended prerequisites for participation** Basic knowledge of elementary linear algebra (matrix multiplication, determination of eigenvalues) is recommended.
4	**Form of examination** Course related exam: • [20-00-1136-iv] (Technical examination, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1136-iv] (Technical examination, 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**

Courses

Course nr.	Course name		
20-00-1136-iv	Introduction to Quantum Computing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ermira Mezini		Integrated course	4

2.3 Optional Subjects AIS-IE: Information Processing in Electrical Power Engineering

Module name Electrical Power Engineering					
Module nr. 18-bi-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** BSc ETiT, BSc WI-ETiT, BSc MEC, BSc iST, BSc CE, MSc ESE
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-bi-1010-vl	Electrical Power Engineering		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Yves Burkhardt		Lecture	3
Course nr.	**Course name**		
18-bi-1010-ue	Electrical Power Engineering		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Yves Burkhardt		Practice	1

Module name 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, 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** BSc ETiT, BSc/MSc WI-ET, BSc EPE, BSc/MSc CE, BSc/MSc iST, MSc Informatik
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	Power Systems I	M.Sc. Felix Korff, Prof. Dr.-Ing. Jutta Hanson, M.Sc. Manuel Schwenke	Lecture	2
18-hs-1010-ue	Power Systems I	Prof. Dr.-Ing. Jutta Hanson	Practice	2

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** BSc ETiT, BSc/MSc Wi-ETiT, BEd
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

<table>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-bt-1020-vl</td><td colspan="3">Course name
Electrical Machines and Drives</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Yves Burkhardt</td><td>Type
Lecture</td><td>SWS
2</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-bt-1020-ue</td><td colspan="3">Course name
Electrical Machines and Drives</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Yves Burkhardt</td><td>Type
Practice</td><td>SWS
2</td></tr>
</table>

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** MSc ETiT, MSc MEC, 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	Instructor	Type	SWS
18-gt-1010-vl	Power Electronics	Prof. Dr.-Ing. Gerd Griepentrog	Lecture	2
18-gt-1010-ue	Power Electronics	Prof. Dr.-Ing. Gerd Griepentrog, M.Sc. Milad Khani	Practice	2

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** BSc 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.	Course name		
	18-kc-1010-vl	High Voltage Technology I		
	Instructor		**Type**	**SWS**
	Prof. Dr. Myriam Koch		Lecture	2
	Course nr.	**Course name**		
	18-kc-1010-ue	High Voltage Technology I		
	Instructor		**Type**	**SWS**
	Prof. Dr. Myriam Koch		Practice	1
	Course nr.	**Course name**		
	18-kc-1010-pr	High Voltage Technology I		
	Instructor		**Type**	**SWS**
	Prof. Dr. Myriam Koch		Internship	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

MSc ETiT, MSc EPE, Wi-ETiT

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					
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

MSc MEC, MSc ETiT

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. 18-gt-2040-vl	**Course name** Real Time Applications and Communication with Microcontrollers and programmable Logic Devices		
	Instructor Prof. Dr.-Ing. Gerd Griepentrog		**Type** Lecture	**SWS** 1
	Course nr. 18-gt-2040-pr	**Course name** Real Time Applications and Communication with Microcontrollers and programmable Logic Devices		
	Instructor Prof. Dr.-Ing. Gerd Griepentrog, Prof. Dr.-Ing. Christian Hochberger		**Type** Internship	**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

MSc ETiT, MSc MEC, MSc EPE

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

<table>
<tr><td colspan="4">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-bt-2010-vl</td><td colspan="3">Course name
Energy Converters - CAD and System Dynamics</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Yves Burkhardt</td><td>Type
Lecture</td><td>SWS
3</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
18-bt-2010-ue</td><td colspan="3">Course name
Energy Converters - CAD and System Dynamics</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Yves Burkhardt</td><td>Type
Practice</td><td>SWS
2</td></tr>
</table>

<table>
<tr><td colspan="6">Module name
Application, Simulation and Control of Power Electronic Systems</td></tr>
<tr><td>Module nr.
18-gt-2030</td><td>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
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 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

MSc ETiT, MSc Wi-ETiT, MSc MEC

8 Grade bonus compliant to §25 (2)

9 References

Definition of project task

Courses

	Course nr.	Course name		
	18-gt-2030-se	Application, Simulation and Control of Power Electronic Systems		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Gerd Griepentrog, M.Sc. Pavel Makin		Seminar	4

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 German/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** MSc ETiT, MSc iST, MSc Wi-ETiT, MSc CE
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	Type	SWS
18-st-2010-vl	Energy Management and Optimization		
Instructor: Prof. Dr. rer. nat. Florian Steinke		Lecture	2
18-st-2010-ue	Energy Management and Optimization		
Instructor: Prof. Dr. rer. nat. Florian Steinke		Practice	1
18-st-2010-pr	Energy Management and Optimization Lab		
Instructor: Prof. Dr. rer. nat. Florian Steinke		Internship	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

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

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

MSc ETiT, MSc EPE, MSc Wi-ETiT

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**
Prof. Dr.-Ing. Jutta Hanson, M.Sc. Soham Choudhury, M.Sc. Anna Pfendler		Lecture	2

	Course nr.	Course name		
	18-hs-2030-ue	Elektrische Energieversorgung II / Power Systems II		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Jutta Hanson, M.Sc. Soham Choudhury, M.Sc. Anna Pfendler		Practice	2

Module name					
Power Laboratory I					
Module nr. 18-bt-2091	**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

Safety instructions for laboratory; Topic of experiments:

- Electrical energy conversion
- Power electronics
- High voltage technology
- Electrical energy supply
- Renewable energies

2 Learning objectives

After completion of the module, the students have learned to work practically in small groups on tasks from electrical power engineering.

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

MSc ETiT, MSc MEC, MSc WI-ETiT

8 Grade bonus compliant to §25 (2)

9 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

Courses

	Course nr. 18-bt-2091-pr	**Course name** Power Laboratory I		
	Instructor Prof. Dr.-Ing. Yves Burkhardt, M.Sc. Alexander Möller		**Type** Internship	**SWS** 3
	Course nr. 18-bt-2090-tt	**Course name** Laboratory Briefing		
	Instructor Prof. Dr.-Ing. Yves Burkhardt		**Type** Tutorial	**SWS** 0

Module name Power Laboratory II					
Module nr. 18-bi-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** MSc ETiT, MSc MEC, MSc WI-ETiT
8	**Grade bonus compliant to §25 (2)**
9	**References** Text book with detailed laboratory instructions

Courses

Course nr.	**Course name**	**Instructor**	**Type**	**SWS**
18-bi-2092-pr	Power Laboratory II	Prof. Dr.-Ing. Yves Burkhardt	Internship	3
18-bt-2090-tt	Laboratory Briefing	Prof. Dr.-Ing. Yves Burkhardt	Tutorial	0

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** MSc ETiT, MSc MEC, MSc Wi-ETiT, MSc ESE, MSc CE
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	

	Course nr. 18-kc-2070-vl	**Course name** Electromagnetic Compatibility		
	Instructor Dr. Ing. Torsten Psotta		**Type** Lecture	**SWS** 2
	Course nr. 18-kc-2070-ue	**Course name** Electromagnetic Compatibility		
	Instructor Dr. Ing. Torsten Psotta		**Type** Practice	**SWS** 1

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** MSc EPE, MSc ETiT, MSc MEC, MSc WI-ETiT
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 Prof. Dr. Georg Traxler-Samek		**Type** Lecture	**SWS** 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					
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** MSc etit, BSc/MSc iST, MSc Wi-etit, MSc ESE
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 M.Sc. Manuel Philipp, Prof. Dr. Claus Neumann		**Type** Lecture	**SWS** 2

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			**Module owner** Prof. Dr. Myriam Koch		

1 Teaching content

Layered Dielectrics, Methods of Field Control and Potential Control, Breakdown in Gases (air and SF6), Breakdown in Vacuum, Surface Discharges, Lightnings and Lightning Protection, Travelling Waves on Conductors; Excursion to a substation

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, 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

MSc ETiT, MSc Wi-ETiT

8 Grade bonus compliant to §25 (2)

9 References

- all lecture slides (ca. 460 pcs.) available for download
- Kind, Feser: High-voltage test techniques, SBA publications
- Kind, Kärner: High-voltage insulation technology, Vieweg

Courses

	Course nr.	Course name		
	18-kc-2010-vl	High Voltage Technology II		
	Instructor		**Type**	**SWS**
	Prof. Dr. Myriam Koch		Lecture	2
	Course nr.	**Course name**		
	18-kc-2010-ue	High Voltage Technology II		
	Instructor		**Type**	**SWS**
	Prof. Dr. Myriam Koch		Practice	1

Module name New Technologies of Electrical Energy Converters and Actuators					
Module nr. 18-bi-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** Goal: The application of new technologies, i.e. super conduction, magnetic levitation techniques and magneto-hydrodynamic converter principles, are introduced to the students. The physical operation mode in principle, implemented prototypes and the current state of the development are described in detail. 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** MSc EPE, MSc ETiT, MSc MEC, MSc WI-ETiT
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.	Course name		
18-bi-2040-vl	New Technologies of Electrical Energy Converters and Actuators		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Yves Burkhardt		Lecture	2
Course nr.	**Course name**		
18-bi-2040-ue	New Technologies of Electrical Energy Converters and Actuators		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Yves Burkhardt		Practice	1

Module name					
Design of Electrical Machines and Actuators with Numerical Field Calculation					
Module nr. 18-bi-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 FEMAG and ANSYS software package 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** MSc EPE, MSc ETiT, MSc MEC
8	**Grade bonus compliant to §25 (2)**
9	**References** Detailed textbook; User manual FEMAG and ANSYS. Müller, C. Groth: FEM für Praktiker - Band 1: Grundlagen, expert-Verlag, 5. Aufl., 2000

Courses

Course nr.	Course name		
18-bi-2110-se	Design of Electrical Machines and Actuators with Numerical Field Calculation		
Instructor		**Type**	**SWS**
Dr.-Ing. Bogdan Funieru		Seminar	2

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** MSc etit, MSc iST, MSc Wi-etit, MSc CE
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. Allan Santos, M.Sc. Tim Janke	Lecture	2
18-st-2020-ue	Machine Learning & Energy	Prof. Dr. rer. nat. Florian Steinke, M.Sc. Allan Santos, M.Sc. Tim Janke	Practice	1
18-st-2020-pr	Machine Learning & Energy Lab	Prof. Dr. rer. nat. Florian Steinke, M.Sc. Allan Santos, M.Sc. Tim Janke	Internship	1

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

MSc ETiT, MSc MEC, MSc Wi-ETiT

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

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-bt-2140-vl</td><td colspan="3">Course name
Electric Railways</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Lecture</td><td>SWS
3</td></tr>
</table>

Module name Physics and Technology of Accelerators					
Module nr. 05-21-2514	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner**		

1	**Teaching content**
2	**Learning objectives**
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Study achievement, p/np RS) Course related exam: • [05-25-6302-pr] (Study achievement, Study achievement, p/np RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Study achievement, Weighting: 100 %) Course related exam: • [05-25-6302-pr] (Study achievement, Study achievement, Weighting: 0 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**	**Instructor**	**Type**	**SWS**
18-bf-2010-vl	Accelerator Physics	Prof. Dr. Oliver Boine-Frankenheim	Lecture	2
05-25-6302-pr	Vocational Laboratory: Introduction to Accelerator Physics		Internship	2
05-21-2502-ku	Introduction to Accelerator Physics		Course	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** MSc etit, BSc/Msc iST, MSc MEC, MSc CE
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. Annette Mütze, Prof. Dr.-Ing. Herbert De Gersem, Prof. Dr. Dr.h.c. Manfred Kaltenbacher, Prof. Dr. rer. nat. Sebastian Schöps		Internship	2

2.4 Optional Subjects AIS-MT: Medical Technics

Module name Visualization in Medicine					
Module nr. 20-00-0467	**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. Bernt Schiele		

1	**Teaching content** Medical Image Data; Image Processing; Medical Visualization with VTK; Indirect Volume Visualization; Direct Volume Visualization; Transfer Functions; Interactive Volume Visualization; Illustrative Rendering; Example: Visualization of Tensor Image Data; Example: Visualization of Tree Structures; Example: Virtual Endoscopy; Image-guided Surgery
2	**Learning objectives** After successfully attending the course, students are familiar with volume visualization techniques. They understand the necessity of image enhancement for the visualization. They can use the “Visualization Toolkit” (VTK) to apply the techniques to implement computing systems for the visualization of medical image data for diagnosis, planning and therapy.
3	**Recommended prerequisites for participation** Useful but not mandatory: GDV I, (Medical) Image processing
4	**Form of examination** Course related exam: • [20-00-0467-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0467-iv] (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 Can 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** Preim, Botha: Visual Computing for Medicine

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

Module name					
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** BSc ETiT, BSc WI-ETiT, BSc MEC
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					
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

BSc ETiT, BSc MEC, BSc CE, BSc 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.	Course name		
	18-kn-1031-pr	Measuring Technique Lab		
	Instructor		**Type**	**SWS**
	Prof. Dr. Mario Kupnik		Internship	2

<table>
<tr><td colspan="6">Module name
Bioinformatics</td></tr>
<tr><td>Module nr.
10-30-0036</td><td>Credit points
4 CP</td><td>Workload
120 h</td><td>Self-study
60 h</td><td>Module duration
1 Term</td><td>Module cycle
Every 2. Semester</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner</td></tr>
</table>

1	**Teaching content**
2	**Learning objectives**
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, 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**

Courses

Course nr.	Course name	Instructor	Type	SWS
10-01-0036-vl	Bio Informatics-Lecture		Lecture	2
10-01-0036-se	Bio Informatics-Exercise		Practice	2

Module name					
Current Trends in Medical Computing					
Module nr. 20-00-0468	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1	**Teaching content** - Participants independently familiarize themselves with a chosen seminar topic by working with the provided initial scientific papers (usually English-language texts) - Deeper and/or wider library research originating from the initially provided papers - Critical discussion of the provided topic - Preparation of a presentation (written text and slides) about the topic - Giving a talk in front of a heterogenous (mixed prior knowledge) audience - Interactive discussion after the presentation - Medical application areas include oncology, orthopedics and navigated surgery. Learning about methods related to medical image processing: segmentation, registration, visualization, simulation, navigation, tracking and others.
2	**Learning objectives** Successful participation in the course enables students to become acquainted with an unfamilar topic by working with scientific papers. They recognize the essential aspects of the examined works and are able to concisely present them to an audience with mixed prior knowledge on the subject. They apply a number of presentation techniques in the process. The students are able to actively guide and participate in a scientific discussion on the presented topic.
3	**Recommended prerequisites for participation** Bachelor from 4. Semester or Master students.
4	**Form of examination** Course related exam: • [20-00-0468-se] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0468-se] (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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**

9	**References** Will be announced in seminar.		
Courses			
	Course nr. 20-00-0468-se	**Course name** Aktuelle Trends im Medical Computing	
	Instructor	**Type** Seminar	**SWS** 2

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** MSc ETiT, MSc MEC, MSc WI-ETiT, MSc Medizintechnik
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 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

MSc ETiT, MSc WI-ETiT, MSc MEC, MSc Medizintechnik

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

Module name					
Deep Learning for Medical Imaging					
Module nr. 20-00-1014	**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. Michael Gösele		

1	**Teaching content** Formulating Medical Image Segmentation, Computer Aided Diagnosis and Surgical Planning as Machine Learning Problems, Deep Learning for Medical Image Segmentation, Deep Learning for Computer Aided Diagnosis, Surgical Planning from pre-surgical images using Deep Learning, Tool presence detection and localization from endoscopic videos using Deep learning, Adversarial Examples for Medical Imaging, Generative Adversarial Networks for Medical Imaging.
2	**Learning objectives** After successful completion of the course, students should be able to understand all components of formulating a Medical Image Analysis problem as a Machine Learning problem. They should also be able to make informed decision of choosing a general purpose deep learning paradigm for given medical image analysis problem.
3	**Recommended prerequisites for participation** - Programming skills - Understanding of Algorithmic design - Linear Algebra - Image Processing / Computer Vision I - Statistical Machine Learning
4	**Form of examination** Course related exam: • [20-00-1014-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1014-iv] (Technical examination, 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)** 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**

Courses

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

Module name 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

MSc (WI-) etit, BSc/MSc iST, MSc iCE, MSc MEC, MSc MedTec

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

<table>
<tr><td colspan="6">Module name
Project Seminar Biophotonics</td></tr>
<tr><td>Module nr.
18-fr-2020</td><td>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
Every Semester</td></tr>
<tr><td colspan="3">Language
German/English</td><td colspan="3">Module owner
Prof. Dr. habil. Torsten Frosch</td></tr>
</table>

<table>
<tr><td>1</td><td>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.</td></tr>
<tr><td>2</td><td>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.</td></tr>
<tr><td>3</td><td>Recommended prerequisites for participation
Module Basics of Optics for Biomedical Engineering</td></tr>
<tr><td>4</td><td>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>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
MSc etit, WI-etit, MSc MEC, MSc Physics, MSc Chemistry, MSc Biomolecular Engineering</td></tr>
<tr><td>8</td><td>Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td>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</td></tr>
<tr><td colspan="2">Courses</td></tr>
</table>

	Course nr.	Course name		
	18-fr-2020-pj	Project Seminar Biophotonics		
	Instructor		**Type**	**SWS**
	Prof. Dr. habil. Torsten Frosch		Project seminar	4

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** BSc iST, MSc ETiT, MSc MEC, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik
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.	Course name		
	18-ad-2020-ue	Fuzzy Logic, Neuronal Networks and Evolutionary Algorithms		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Jürgen Adamy		Practice	1

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** MSc MedTec, BSc/MSc 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 Prof. Dr.-Ing. Christoph Hoog Antink		**Type** Project seminar	**SWS** 4

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

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

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					
Computational Modeling for the IGEM Competition					
Module nr. 18-kp-2100	**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. techn. Heinz Köppl		

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

BSc etit, MSc etit

8 Grade bonus compliant to §25 (2)

9 References

Courses

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-kp-2100-se</td><td colspan="3">Course name
Computational Modeling for the IGEM Competition</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. techn. Heinz Köppl</td><td>Type
Seminar</td><td>SWS
2</td></tr>
</table>

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

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

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 Computer-aided planning and navigation in medicine					
Module nr. 20-00-0677	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Georgios Sakas		

1	**Teaching content** - Participants independently familiarize themselves with a chosen seminar topic by working with the provided initial scientific papers (usually English-language texts) - Deeper and/or wider library research originating from the initially provided papers - Critical discussion of the provided topic - Preparation of a presentation (written text and slides) about the topic - Giving a talk in front of a heterogenous (mixed prior knowledge) audience - Interactive discussion after the presentation Learning about methods related to planning and navigation are: segmentation, registration, visualization, simulation, navigation, tracking and others.
2	**Learning objectives** Successful participation in the course enables students to become acquainted with an unfamilar topic by working with scientific papers. They recognize the essential aspects of the examined works and are able to concisely present them to an audience with mixed prior knowledge on the subject. They apply a number of presentation techniques in the process. The students are able to actively guide and participate in a scientific discussion on the presented topic.
3	**Recommended prerequisites for participation** Bachelors: >=4th semester Masters: >=1st semester
4	**Form of examination** Course related exam: • [20-00-0677-se] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0677-se] (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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**

<table>
<tr><td>9</td><td colspan="4">References
Will be given in seminar.</td></tr>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
20-00-0677-se</td><td colspan="3">Course name
Computer-aided planning and navigation in medicine</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. Georgios Sakas</td><td>Type
Seminar</td><td>SWS
2</td></tr>
</table>

Module name Medical Image Processing					
Module nr. 20-00-0379	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1	**Teaching content** The lecture consists of two parts. The first half of the lecture describes how devices that yield medical image data (CT, NMR, PET, SPECT, Ultrasound) work. The second half of the lecture covers various image processing techniques that are typically applied to medical images.
2	**Learning objectives** After successfully completing the course, students have an overview over the mechanisms used in and the abilities of modern medical image processing techniques. They are able to solve basic to medium level problems in medical image processing.
3	**Recommended prerequisites for participation** Basics within Mathematics are highly recommended. Participation in lecture "Bildverarbeitung".
4	**Form of examination** Course related exam: • [20-00-0379-vl] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0379-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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References** 1) Heinz Handels: Medizinische Bildverarbeitung 2) 2) Gonzalez/Woods: Digital Image Processing (last edition) 3) 3) Bernd Jähne: Digitale Bildverarbeitung. 6. überarbeitete und erweiterte Auflage. Springer, Berlin u. a. 2005, ISBN 3-540-24999-0 4) Kristian Bredies, Dirk Lorenz: Mathematische Bildverarbeitung. Einführung in Grundlagen und moderne Theorie. Vieweg+Teubner, Wiesbaden 2011, ISBN 978-3-8348-1037-3
Courses	

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

<table>
<tr><td colspan="7">Module name
Analysis and Synthesis of Human Movements I</td></tr>
<tr><td colspan="2">Module nr.
03-04-0580</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="4">Language
German/English</td><td colspan="3">Module owner
Prof. Dr. phil. André Seyfarth</td></tr>
<tr><td>1</td><td colspan="6">Teaching content</td></tr>
<tr><td>2</td><td colspan="6">Learning objectives</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
Course related exam:
• [03-41-0580-se] (Study achievement, Optional, 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
Course related exam:
• [03-41-0580-se] (Study achievement, Optional, Weighting: 1)</td></tr>
<tr><td>7</td><td colspan="6">Usability of the module</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</td></tr>
<tr><td colspan="7">Courses</td></tr>
<tr><td rowspan="2"></td><td colspan="2">Course nr.
03-41-0580-se</td><td colspan="4">Course name
Einführung in die biomechanische Bewegungserfassung und -analyse</td></tr>
<tr><td colspan="4">Instructor</td><td>Type
Seminar</td><td>SWS
2</td></tr>
</table>

Module name Deep Generative Models					
Module nr. 20-00-1035	**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.-Ing. Michael Gösele		

1	**Teaching content** Generative Models, Implicit and Explicit Models, Maximum Likelihood, Variational AutoEncoders, Generative Adversarial networks, Numerical Optimization for Generative models, Applications in medical Imaging
2	**Learning objectives** After students have attended the module, they can - Explain the structure and operation of Deep Generative Models (DGM) - Critically scrutinize scientific publications on the topic of DGMs and thus assess them professionally - independently construct / implement basic DTMs in a high-level programming language designed for this purpose - Transfer the implementation and application of DTMs to different applications
3	**Recommended prerequisites for participation** - Python Programming - Linear Algebra - Image Processing/Computer Vision I - Statistical Machine Learning
4	**Form of examination** Course related exam: • [20-00-1035-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1035-iv] (Technical examination, 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)** 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** No textbooks as such. Online materials will be made available during the course.

Courses

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

<table>
<tr><td colspan="6">Module name
Basics of Biophotonics</td></tr>
<tr><td>Module nr.
18-fr-2010</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. habil. Torsten Frosch</td></tr>
</table>

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, multi-photon 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** MSc (WI-) etit, MSc MEC, MSc MedTec, BSc/MSc 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 Prof. Dr. habil. Torsten Frosch		**Type** Lecture	**SWS** 2
	Course nr. 18-fr-2010-ue	**Course name** Basics of Biophotonics		
	Instructor Prof. Dr. habil. Torsten Frosch		**Type** Practice	**SWS** 1

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** MSc MedTec, BSc/MSc iST, MSc MEC
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	Internship	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** BSc Biomedical Engineering
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

2.5 Optional Subjects AIS-CSR: Control Systems and Robotics

Module name Foundations of Robotics					
Module nr. 20-00-0735	**Credit points** 10 CP	**Workload** 300 h	**Self-study** 210 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1	**Teaching content** This course covers spatial representations and transformations, manipulator kinematics, vehicle kinematics, velocity kinematics, Jacobian matrix, robot dynamcis, robot sensors and actuators, robot control, path planning, localization and navigation of mobile robots, robot autonomy and robot development. Theoretical and practical assignments as well as programming tasks serve for deepening of the understanding of the course topics.
2	**Learning objectives** After successful participation, students possess the basic technical knowledge and methodological skills necessary for fundamental investigations and engineering developments in robotics in the fields of modeling, kinematics, dynamics, control, path planning, navigation, perception and autonomy of robots.
3	**Recommended prerequisites for participation** Recommended: basic mathematical knowledge and skills in linear algebra, multi-variable analysis and fundamentals of ordinary differential equations
4	**Form of examination** Course related exam: • [20-00-0735-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0735-iv] (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 Can 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**

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

Module name 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

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

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

<table>
<tr><td rowspan="2"></td><td>Course nr.
18-ad-1010-ue</td><td colspan="3">Course name
System Dynamics and Automatic Control Systems II</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Jürgen Adamy</td><td>Type
Practice</td><td>SWS
2</td></tr>
</table>

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

BSc ETiT; BSc MEC

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. 18-fi-1030-pr	**Course name** Laboratory Matlab/Simulink I		
Instructor M.Sc. Alexander Steinke, Prof. Dr.-Ing. Rolf Findeisen		**Type** Internship	**SWS** 3

<table>
<tr><td colspan="6">Module name
Laboratory Control Engineering I</td></tr>
<tr><td>Module nr.
18-fi-1020</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. Rolf Findeisen</td></tr>
</table>

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** BSc ETiT
8	**Grade bonus compliant to §25 (2)**
9	**References** Lab handouts will be given to students.

Courses

<table>
<tr><td colspan="2">Course nr.
18-ko-1020-pr</td><td colspan="2">Course name
Laboratory Control Engineering I</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr.-Ing. Ulrich Konigorski</td><td>Type
Internship</td><td>SWS
4</td></tr>
</table>

Module name Integrated Robotics Project 1					
Module nr. 20-00-0324	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1	**Teaching content** - guided independent work on a concrete task from development and application of modern robotic systems and, as far as possible, as member of a team of developers - becoming acquainted with the relevant state of research and technology - development of a solution approach and its implementation - application and evaluation based on robot experiments or simulations - documentation of task, approach, implementation and results in a final report and conduction of a final presentation
2	**Learning objectives** Through successful participation students acquire deepened knowledge in selected areas, subsystems and methods of modern robotic systems as well as in-depth skills for development, implementation, and experimental evaluation. They train presentation skills and, as far as possible, team work.
3	**Recommended prerequisites for participation** - basic knowledge within Robotics as given in lecture “Grundlagen der Robotik” - programming skills depending on task
4	**Form of examination** Course related exam: • [20-00-0324-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0324-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** Will be given in lecture.
Courses	

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

Module name					
Integrated Robotics Project 2					
Module nr. 20-00-0357	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1	**Teaching content** - guided independent work on a concrete task from development and application of modern robotic systems and, as far as possible, as member of a team of developers - becoming acquainted with the relevant state of research and technology - development of a solution approach and its implementation - application and evaluation based on robot experiments or simulations - documentation of task, approach, implementation and results in a final report and conduction of a final presentation
2	**Learning objectives** Through successful participation students acquire deepened knowledge in selected areas, subsystems and methods of modern robotic systems as well as in-depth skills for development, implementation, and experimental evaluation. They train presentation skills and, as far as possible, team work.
3	**Recommended prerequisites for participation** - basic knowledge within Robotics as given in lecture “Grundlagen der Robotik” - programming skills depending on task - Participation in "Integriertes Robotik-Project 1"
4	**Form of examination** Course related exam: • [20-00-0357-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0357-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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be given in course.
Courses	

	Course nr.	Course name		
	20-00-0357-pr	Integrated Project (Part 2)		
	Instructor		**Type**	**SWS**
			Internship	4

Module name Laboratory Control Engineering II					
Module nr. 18-ad-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. Jürgen Adamy		

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

MSc ETiT, MSc MEC, MSc iST, MSc Wi-ETiT, Biotechnik

8 Grade bonus compliant to §25 (2)

9 References

Adamy: Instruction manuals for the experiments (available during the kick-off meeting)

Courses

Course nr.	**Course name**		
18-ad-2060-pr	Laboratory Control Engineering II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jürgen Adamy, M.Sc. Nikolas Hohmann		Internship	4

<table>
<tr><td colspan="6">Module name
Control of Drives</td></tr>
<tr><td>Module nr.
18-gt-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
Summer term</td></tr>
<tr><td colspan="3">Language
English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Gerd Griepentrog</td></tr>
</table>

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

MSc ETiT, MSc EPE, MSc MEC, Wi-ETiT

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					
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

MSc etit, MSc MEC

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		Internship	4

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

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					
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**
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**
Dr. Ing. Eric Lenz, Prof. Dr.-Ing. Rolf Findeisen		Lecture	3

	Course nr.	Course name		
	18-fi-2030-ue	Modeling, Simulation, and Optimization		
	Instructor		**Type**	**SWS**
	Dr. Ing. Eric Lenz, Prof. Dr.-Ing. Rolf Findeisen		Practice	2

Module name					
System Dynamics and Automatic Control Systems III					
Module nr. 18-ad-2010	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**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

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

8 Grade bonus compliant to §25 (2)

9 References

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

Courses

Course nr.	Course name		
18-ad-2010-vl	System Dynamics and Automatic Control Systems III		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jürgen Adamy, M.Sc. Karsten Kreutz		Lecture	2

	Course nr.	Course name		
	18-ad-2010-ue	System Dynamics and Automatic Control Systems III		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Jürgen Adamy, M.Sc. Karsten Kreutz		Practice	1

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** MSc ETiT, MSc MEC
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 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

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

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

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** MSc ETiT, MSc MEC, MSc WI-ETiT
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		Internship	3

	Course nr.	Course name		
	18-bt-2090-tt	Laboratory Briefing		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Yves Burkhardt		Tutorial	0

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

Module name Measuring Technique					
Module nr. 18-kn-1011	**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. Mario Kupnik		

1 Teaching content

The module includes theoretical discussion and practical application of the measuring chain in detail on example the electrical variables (current, voltage, impedance, power) and selected non-electrical variables (frequency, time, force, pressure and acceleration).
In the lecture the following chapter will be thematically treated measuring signals and measuring equipment (oscilloscope, laboratory testing equipment), static measurement error and disturbance variables (especially temperature), basic measurement circuits, AD conversion principles and filtering, measurement method non-electrical variables and the statistics of measurements (distributions, statist safe tests).
The topics of the lecture are discussed in the exercise of the module. Examples are analyzed and their application in measurement scenarios are practiced.
The practicum of the module consists of five experiments which are time closely matched in time to the lecture:

- Measuring of signals in the time range with digital storage oscilloscope, trigger conditions
- Measuring of signals in the frequency range with digital storage oscilloscope, error of measurement (aliasing / subsampling, leackage) and window functions
- Measuring of mechanical dimensions with suitable primary sensors, sensor electronics / amplifier circuits
- computer-based measuring
- Importing of sensor signals, whose processing and the resulting automated control of a process using a programmable logic controller (PLC)

2 Learning objectives

The students know the structure of the measuring chain and the specific properties of the corresponding elements. They know the structure of electronic measuring instruments and basic measuring circuits for electrical and selected non-electrical variables and can apply them. They know the basics of capturing, processing, transferring and storage of measurement data and can describe error sources and quantifying their influences.
In the practicum, the students deepen the basis of the measurements with the oscilloscope, the understanding of the relationship between time and frequency range. Methodically they are able to document and evaluate the data during laboratory measuring.

3 Recommended prerequisites for participation

Basics of ETiT I-III, Math I-III, Electronic

4 Form of examination

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

Course related exam:
- [18-kn-1011-pr] (Study achievement, Optional, 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: 4)

Course related exam:
- [18-kn-1011-pr] (Study achievement, Optional, Weighting: 2)

7 Usability of the module

<table>
<tr><td></td><td colspan="3">BSc ETiT, BSc Wi-ETiT, BSc MEC</td></tr>
<tr><td>8</td><td colspan="3">Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td colspan="3">References
Slide set of lecture
Textbook and exercise book Lerch: „Elektrische Messtechnik“, Springer
Exercise documents
Practical experiment manuals</td></tr>
<tr><td colspan="4">Courses</td></tr>
<tr><td></td><td>Course nr.
18-kn-1011-vl</td><td colspan="2">Course name
Measuring Technique</td></tr>
<tr><td></td><td colspan="2">Instructor
Prof. Dr. Mario Kupnik</td><td>Type
Lecture</td><td>SWS
2</td></tr>
<tr><td></td><td>Course nr.
18-kn-1011-ue</td><td colspan="2">Course name
Measuring Technique</td></tr>
<tr><td></td><td colspan="2">Instructor
Prof. Dr. Mario Kupnik</td><td>Type
Practice</td><td>SWS
1</td></tr>
<tr><td></td><td>Course nr.
18-kn-1011-pr</td><td colspan="2">Course name
Measuring Technique Lab</td></tr>
<tr><td></td><td colspan="2">Instructor
Prof. Dr. Mario Kupnik</td><td>Type
Internship</td><td>SWS
2</td></tr>
</table>

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** BSc ETiT, BSc WI-ETiT, MSc MEC
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**	**Instructor**	**Type**	**SWS**
18-kn-1050-vl	Electromechanical Systems I	M.Sc. Omar Dali, Prof. Dr. techn. Dr.h.c. Andreas Binder, Prof. Dr. Mario Kupnik	Lecture	2
18-kn-1050-ue	Electromechanical Systems I	M.Sc. Omar Dali, Prof. Dr. techn. Dr.h.c. Andreas Binder, Prof. Dr. Mario Kupnik	Practice	2

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** BSc ETiT, BSc 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		
18-dg-1010-vl	Introduction to Electrodynamics		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Herbert De Gersem		Lecture	2

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

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

Module name Railway Vehicle Engineering					
Module nr. 18-bi-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** MSc ETiT, MSc MEC, MSc EPE, MSc WI-ETiT
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-bi-2050-vl	Railway Vehicle Engineering		
Instructor		**Type**	**SWS**
Dr.-Ing. Michael Karatas		Lecture	2

Module name					
Data-driven Modelling of Dynamic Systems					
Module nr. 18-fi-2090	**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. 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, 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** MSc etit, MSc MEC
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. 18-fi-2090-vl	**Course name** Data-driven Modelling of Dynamic Systems		
	Instructor Dr. Ing. Eric Lenz		**Type** Lecture	**SWS** 2
	Course nr. 18-fi-2090-ue	**Course name** Data-driven Modelling of Dynamic Systems		
	Instructor Dr. Ing. Eric Lenz		**Type** Practice	**SWS** 1

Module name					
New Technologies of Electrical Energy Converters and Actuators					
Module nr. 18-bi-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

Goal: The application of new technologies, i.e. super conduction, magnetic levitation techniques and magneto-hydrodynamic converter principles, are introduced to the students. The physical operation mode in principle, implemented prototypes and the current state of the development are described in detail.

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

MSc EPE, MSc ETiT, MSc MEC, MSc WI-ETiT

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.	**Course name**		
18-bi-2040-vl	New Technologies of Electrical Energy Converters and Actuators		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Yves Burkhardt		Lecture	2
Course nr.	**Course name**		
18-bi-2040-ue	New Technologies of Electrical Energy Converters and Actuators		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Yves Burkhardt		Practice	1

Module name					
Design of Electrical Machines and Actuators with Numerical Field Calculation					
Module nr. 18-bi-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 FEMAG and ANSYS software package 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** MSc EPE, MSc ETiT, MSc MEC
8	**Grade bonus compliant to §25 (2)**
9	**References** Detailed textbook; User manual FEMAG and ANSYS. Müller, C. Groth: FEM für Praktiker - Band 1: Grundlagen, expert-Verlag, 5. Aufl., 2000

Courses

Course nr.	Course name		
18-bi-2110-se	Design of Electrical Machines and Actuators with Numerical Field Calculation		
Instructor		**Type**	**SWS**
Dr.-Ing. Bogdan Funieru		Seminar	2

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** BSc MEC
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**		
18-bt-1030-pr	Actuators for Mechatronic Systems Laboratory		
Instructor Prof. Dr.-Ing. Yves Burkhardt		**Type** Internship	**SWS** 3
Course nr. 18-bt-2090-tt	**Course name** Laboratory Briefing		
Instructor Prof. Dr.-Ing. Yves Burkhardt		**Type** Tutorial	**SWS** 0

Module name					
Planning and Application of Electrical Drives (Drives for Electric Vehicles)					
Module nr. 18-bi-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** MSc ETiT, MSc MEC, MSc EPE, MSc WI-ETiT
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-bi-2120-se	Planning and application of electrical drives (Drives for electric vehicles)		
Instructor		**Type** Seminar	**SWS** 2

Module name Project Seminar Automatic Control Systems					
Module nr. 18-ad-2080	**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. Jürgen Adamy		

1	**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.
2	**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.
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** MSc ETiT, MSc MEC, MSc iST, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik
8	**Grade bonus compliant to §25 (2)**
9	**References** Training course material

Courses

Course nr.	**Course name**		
18-ad-2080-pj	Project Seminar Automatic Control Systems		
Instructor Prof. Dr.-Ing. Jürgen Adamy		**Type** Project seminar	**SWS** 4

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** MSc etit, MSc MEC, MSc 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**
Prof. Dr.-Ing. Rolf Findeisen, M.Sc. Julian Zeiß		Project seminar	4

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** MSc ETiT
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					
Machine Learning and Deep Learning for Automation Systems					
Module nr.	**Credit points**	**Workload**	**Self-study**	**Module duration**	**Module cycle**
18-ad-2100	3 CP	90 h	60 h	1 Term	Summer term
Language			**Module owner**		
German			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

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 Robot Learning: Integrated Project - Part 1					
Module nr. 20-00-0753	**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. Oskar von Stryk		

1	**Teaching content** In "Robot Learning: Integrated Project, Part 1", students will pose a current research problem in the domain of robot learning with assistance of their advisor. The students will select a robot learning topic to fit their research interests, on which they will pursue in-depth literature studies. Using these results, they will develop a plan for their project, try out the algorithms of interest and implement a prototype in simulation.
2	**Learning objectives** Upon successful completion of this course, students will be able to independently develop small research projects in the domain of robot learning and test first research ideas in simulation.
3	**Recommended prerequisites for participation** Previous or concurrent participation in the lecture "Robot Learning".
4	**Form of examination** Course related exam: • [20-00-0753-pj] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0753-pj] (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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	**Course name**		
20-00-0753-pj	Robot Learning: Integrated Project - Part 1		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Oskar von Stryk		Project	4

Module name					
Robot Learning: Integrated Project - Part 2					
Module nr. 20-00-0754	**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. Oskar von Stryk		

1	**Teaching content** In "Robot Learning: Integrated Project, Part 2", students will complete their approach to the research problem from Part 1 and apply it to a real robot. A scientific article on the research problem, methods and results will be written and potentially submitted to a national or international scientific venue.
2	**Learning objectives** Upon successful completion of this course, students will be able to independently develop small research projects in the domain of robot learning and test first research ideas in simulation.
3	**Recommended prerequisites for participation** Previous or concurrent participation in the lecture "Robot Learning".
4	**Form of examination** Course related exam: • [20-00-0754-pj] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0754-pj] (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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
20-00-0754-pj	Robot Learning: Integrated Project - Part 2		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Oskar von Stryk		Project	4

Module name					
Computational Engineering and Robotics					
Module nr. 20-00-0011	**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. phil. nat. Marc Fischlin		

1	**Teaching content** - Foundations of modelling and simulation - Problem specification and system description for computational engineering - Model generation for the example of mechanical systems - Model analysis for the example of mechanical systems - Implementations of simulations for the example of robots and other systems - Interpretation and validation using measurement data - Applications in simulation and control of robots as well as in physically based animation and computer games
2	**Learning objectives** Upon successful completion of this class, students will be able to develop first models and simulations and can perform first simulation studies within robotics. They know the necessary key steps needed to construct simulations (problem specification, model generation, model analysis, implementation, and validation) and can use them to construct first simulations to meet the specification requirements.
3	**Recommended prerequisites for participation**
4	**Form of examination** Course related exam: • [20-00-0011-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0011-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. Informatik B.Sc. Wirtschaftsinformatik B.Sc. Computational Engineering B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik B.Sc. Informationssystemtechnik 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** F. Föllinger: Einführung in die Zustandsbeschreibung dynamischer Systeme (Oldenbourg, 1982) P. Corke: Robotics, Vision & Control, Springer, 2011 F.L. Severance: System Modeling and Simulation: An Introduction, J. Wiley & Sons, 2001

Courses				
	Course nr. 20-00-0011-iv	**Course name** Computational Engineering and Robotics		
	Instructor		**Type** Integrated course	**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** Dr.-Ing. Nicklas Norrick		

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 Robot Learning					
Module nr. 20-00-0629	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner**		

1	**Teaching content** - Foundations from robotics and machine learning for robot learning - Learning of forward models - Representation of a policy, hierarchical abstraction wiith movement primitives - Imitation learning - Optimal control with learned forward models - Reinforcement learning and policy search - Inverse reinforcement learning
2	**Learning objectives** Upon successful completion of this course, students are able to understand the relevant foundations of machine learning and robotics. They will be able to use machine learning approaches to empower robots to learn new tasks. They will understand the foundations of optimal decision making and reinforcement learning and can apply reinforcement learning algorithms to let a robot learn from interaction with its environment. Students will understand the difference between Imitation Learning, Reinforcement Learning, Policy Search and Inverse Reinforcement Learning and can apply each of this approaches in the appropriate scenario.
3	**Recommended prerequisites for participation** Good programming in Matlab Lecture Machine Learning 1 - Statistical Approaches is helpful but not mandatory.
4	**Form of examination** Course related exam: • [20-00-0629-vl] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0629-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 Can 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** Deisenroth, M. P.; Neumann, G.; Peters, J. (2013). A Survey on Policy Search for Robotics, Foundations and Trends in Robotics Kober, J; Bagnell, D.; Peters, J. (2013). Reinforcement Learning in Robotics: A Survey, International Journal of Robotics Research C.M. Bishop, Pattern Recognition and Machine Learning (2006), R. Sutton, A. Barto. Reinforcement Learning - an Introduction Nguyen-Tuong, D.; Peters, J. (2011). Model Learning in Robotics: a Survey

Courses

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

Module name Physics and Technology of Accelerators					
Module nr. 05-21-2514	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner**		

1	**Teaching content**
2	**Learning objectives**
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Study achievement, Study achievement, p/np RS) Course related exam: • [05-25-6302-pr] (Study achievement, Study achievement, p/np RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Study achievement, Study achievement, Weighting: 100 %) Course related exam: • [05-25-6302-pr] (Study achievement, Study achievement, Weighting: 0 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name	Instructor	Type	SWS
18-bf-2010-vl	Accelerator Physics	Prof. Dr. Oliver Boine-Frankenheim	Lecture	2
05-25-6302-pr	Vocational Laboratory: Introduction to Accelerator Physics		Internship	2
05-21-2502-ku	Introduction to Accelerator Physics		Course	2

Module name Optimization of static and dynamic systems					
Module nr. 20-00-0186	**Credit points** 10 CP	**Workload** 300 h	**Self-study** 210 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1	**Teaching content** optimization for static systems: - unconstrained and constrained nonlinear optimization, optimality conditions - numerical Newton type and SQP methods - nonlinear least squares - gradient free optimization methods - practical aspects like problem formulation, approximation of derivatives, method specific parameters, assessment of a computed solution optimization for dynamic systems: - parameter optimization and estimation problems - optimal control problem - maximum principle and optimality conditions - numerical methods for computing optimal trajectories - optimal feedback control - linear quadratic regulator applications and case studies from engineering sciences and robotics theoretical and practical assignments as well as programming tasks for deepening of knowledge and methodological skills
2	**Learning objectives** Through successful participation students acquire fundamental knowledge and methodological skills in concepts, techniques and computational methods of optimization for static and dynamic systems and their application for optimization problems in engineering sciences.
3	**Recommended prerequisites for participation** grundlegende mathematische Kenntnisse und Fähigkeiten in Linearer Algebra, Analysis mehrerer Veränderlicher und Grundlagen gewöhnlicher Differentialgleichungen
4	**Form of examination** Course related exam: • [20-00-0186-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0186-iv] (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)** 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** - Script of Lecture - J. Nocedal, S.J. Wright: Numerical Optimization, Springer - C.T. Kelley: Iterative Methods for Optimization, SIAM Frontiers in Applied Mathematics - L.M. Rios, N.V. Sahinidis: Derivative-free optimization: a review of algorithms and comparison of software implementations, Journal of Global Optimization (2013) 56:1247-1293 - A.E. Bryson, Y.-C. Ho: Applied Optimal Control: Optimization, Estimation and Control, CRC Press - J.T. Betts: Practical Methods for Optimal Control and Estimation Using Nonlinear Programming, SIAM Advances in Design and Control

Courses

Course nr.	Course name		
20-00-0186-iv	Optimization of static and dynamic systems		
Instructor		**Type**	**SWS**
		Integrated course	6

Module name Computer Aided Design (CAD)					
Module nr. 16-07-5020	**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. Dipl-Wirt.-Ing. Benjamin Schleich		

1	**Teaching content** Parametric 3D CAD systems, PDM systems, 3D hand sketching, geometric models, design of single parts with geometric elements, features and parametrics, assembly modeling, bill of materials, tolerances and surface fits, technical product documentation, drawing standards, product development in teams.
2	**Learning objectives** On successful completion of this module, students should be able to: 1. Understand and apply parametric 3D CAD and PDM systems. 2. Design parametric single parts and complex assemblies. 3. Create engineering drawings for documentation. 4. Manage generated product data using PDM processes. 5. Work on and solve advanced tasks in virtual product development in teams.
3	**Recommended prerequisites for participation**
4	**Form of examination** Module exam: • Module exam (Technical examination, Special form, Default RS) Product modelling project (continuous assessment procedure: Reports on component modeling, assembly.
5	**Prerequisite for the award of credit points** Passing the examination
6	**Grading** Module exam: • Module exam (Technical examination, Special form, Weighting: 100 %)
7	**Usability of the module** Bachelor MB Pflicht Bachelor WI-MB WP Projekte Bachelor Mechatronik
8	**Grade bonus compliant to §25 (2)**
9	**References** Lecture notes can be purchased in the institute's secretarial office. Exercises and background theory are available on the website.

Courses

Course nr.	Course name	Instructor	Type	SWS
16-07-5020-vl	Computer Aided Design (CAD)		Lecture	1
16-07-5020-ue	Computer Aided Design (CAD)		Practice	1

<table>
<tr><td rowspan="2"></td><td>Course nr.
16-07-5020-tt</td><td colspan="3">Course name
Computer Aided Design (CAD)</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Tutorial</td><td>SWS
2</td></tr>
</table>

Module name Fundamentals of Navigation I					
Module nr. 16-23-5050	**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 Beyer		

1	**Teaching content** Navigation principles, Earth models, Coordinate systems, Radio navigation, Basics and instruments (ADF, VOR, DME, ILS), dead reckoning, functional principles and error analysis, satellite navigation, Introduction into GPS, signal description and measurement principles, Dilution of Precision (DoP), Differential GPS, Augmentation systems (RAIM, GIC, WAAS, LAAS, EGNOS).
2	**Learning objectives** On successful completion of this module, students should be able to: 1. Explain the physics associated with the navigation of the earth. 2. Classify common coordinate systems and map projections. 3. Judge the methods of radio, coupling, and satellite navigation with respect to performance and applications.
3	**Recommended prerequisites for participation** Recommanded: Control Engineering
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral examination, Duration: 20 Min., Default RS) Oral exam (in a group with 3 students) 60 min: 20 min per participiant
5	**Prerequisite for the award of credit points** Passing the examination
6	**Grading** Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %)
7	**Usability of the module** WPB Master MB III (Wahlfächer aus Natur- und Ingenieurwissenschaft) WPB Master AE III Nat_Ing-Bereich WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik) Master Mechatronik
8	**Grade bonus compliant to §25 (2)**
9	**References** Course notes available.

Courses

Course nr.	**Course name**		
16-23-5050-vl	Fundamentals of Navigation I		
Instructor		**Type** Lecture	**SWS** 2

Course nr.	**Course name**		
16-23-5050-ue	Fundamentals of Navigation I		
Instructor		**Type** Practice	**SWS** 1

Module name					
Tutorial Advanced Cax Methods					
Module nr. 16-07-5100	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr.-Ing. Dipl-Wirt.-Ing. Benjamin Schleich		

1	**Teaching content** Students gain knowledge of advanced CA Methods through the analysis of recent industrial examples. This course builds on the basic course 'Einführung in das rechnerunterstützte Konstruieren (CAD)'.
2	**Learning objectives** The students will be familiar with advanced CA Methods. They are able to recognise, execute and plan the generic workflow of CA Processes. Furthermore they are able to transfer their theoretical knowledge into industrial practice.
3	**Recommended prerequisites for participation** Einführung in das rechnergestützte Konstruieren (CAD) Virtuelle Produktentwicklung A, B, C
4	**Form of examination** Module exam: • Module exam (Technical examination, Special form, Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Special form, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
16-07-5100-tt	Tutorial Advanced CAx Methods		
Instructor		**Type** Tutorial	**SWS** 4

Module name Hands-On HCI					
Module nr. 20-00-1116	**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. Arjan Kuijper		

1	**Teaching content** You might have previously heard of or even tried out virtual/augmented reality, 3D printing, wearable or tangible user interfaces. The area of Human-Computer Interaction covers all these exciting topics and offers an opportunity to build new prototypes and try them out with people in the user studies. If you would like to better connect theory and practice in the area of Human-Computer Interaction (HCI), then the course of Hands-On Human-Computer Interaction (Hands-On HCI) is for you. The goal of the class is to walk you through the whole research cycle in HCI. It can play a great preparation role for your future bachelor/master thesis in HCI or lay a first brick in your academic path after finishing your studies.
2	**Learning objectives** After completing the module, students can - differentiate between and apply three approaches to HCI research. - distinguish three types of empirical research. - effectively read a scientific publication. - differentiate between types of HCI contributions. - Formulate and define research questions, hypotheses and experimental variables. - create a suitable study design based on the previously developed research questions. - conduct a study using quantitative and qualitative methods to collect data. - Analyze, evaluate and interpret quantitative data on the basis of statistical methods. - Analyze and interpret qualitative data on the basis of grounded theory. - Understand the peer review process and write reviews for a scientific publication. - Understand and apply evaluation techniques with and without users. - Write the knowledge gained as a scientific publication and present it to a specialist audience.
3	**Recommended prerequisites for participation** Recommended: Human-Computer Interaction (TK2)
4	**Form of examination** Course related exam: • [20-00-1116-iv] (Technical examination, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1116-iv] (Technical examination, 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**

Courses

Course nr.	Course name		
20-00-1116-iv	Hands-On HCI		
Instructor		**Type**	**SWS**
Prof. Dr. Arjan Kuijper		Integrated course	4

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**
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		Practice	1

2.6 Optional Subjects AIS-SS: Secure Systems

Module name IT Security					
Module nr. 20-00-0219	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Dr.-Ing. Michael Kreutzer		

1	**Teaching content** Selected concepts of IT-Security (cryptography, security models, authentication, access control, security in networks; trusted computing, security engineering, privacy, web and browser security, information security management, IT forensic, cloud computing)
2	**Learning objectives** After successful participation in the course, students are versant in common mechanisms and protocols to increase security in modern it-systems. Students have broad knowledge of it-security, data protection and privacy on the Internet. Students are familiar with modern information technology security concepts from the field of cryptography, identity management, web, browser and network security. Students are able to identify attack vectors in it-systems and develop countermeasures.
3	**Recommended prerequisites for participation** Participation of lecture Trusted Systems
4	**Form of examination** Course related exam: • [20-00-0219-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0219-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 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**

- C. Eckert: IT-Sicherheit, 3. Auflage, Oldenbourg Verlag, 2004
- J. Buchmann, Einführung in die Kryptographie, 2.erw. Auflage, Springer Verlag, 2001
- E. D. Zwicky, S. Cooper, B. Chapman: Building Internet Firewalls, 2. Auflage, O'Reilly, 2000
- B. Schneier, Secrets & Lies: IT-Sicherheit in einer vernetzten Welt, dpunkt Verlag, 2000
- W. Rankl und W. Effing: Handbuch der Chipkarten, Carl Hanser Verlag, 1999
- S. Garfinkel und G. Spafford: Practical Unix & Internet Security, O'Reilly & Associates

Courses

Course nr.	**Course name**		
20-00-0219-iv	IT Security		
Instructor		**Type**	**SWS**
		Integrated course	4

Module name					
Physical Layer Security in Wireless Systems					
Module nr. 20-00-0745	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Dr.-Ing. Michael Kreutzer		

1 Teaching content

Physical layer security techniques promise information theoretic security on the physical layer for wireless communication. This integrated course discusses the theory and practice of physical layer security. The underlying theory is introduced and the application of these fundamentals towards practical solutions is discussed. Attacks against (practical) physical layer security techniques are presented. Theoretical and practical exercises as well as the presentation of selected recent research results by seminar talks of students further deepen the understanding of the subject matter.

Course contents:
- Properties of the physical layer
- Fundamentals of information theoretic security and delineation from cryptography
- Physical layer security techniques (such as cooperative jamming, orthogonal blinding, zero-forcing, interference alignment, key extraction)
- Practical aspects of physical layer security techniques
- Practical implementations of physical layer security techniques using software-defined radios
- Selected current approaches to physical layer security

2 Learning objectives

After successfully attending the course, students have a basic theoretical knowledge and an in-deep practical knowledge in the area of physical layer security. They are able to describe the most important information-theoretic basics as well as theory and practice of physical layer security techniques. They are able to analyze practical physical layer security techniques and describe their weaknesses. Students have competencies in the practical realization of physical layer security techniques using software-defined radios. They can independently acquire the current state of research on physical layer security and present the aquired knowledge in a comprehensible fashion.

3 Recommended prerequisites for participation

Basics Mobile Networking

4 Form of examination

Course related exam:
- [20-00-0745-iv] (Technical examination, Oral/written examination, Default RS)

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:
- [20-00-0745-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 Can 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** Selected literature, will be given in lecture.

Courses

Course nr.	**Course name**		
20-00-0745-iv	Physical Layer Security in Wireless Systems		
Instructor		**Type**	**SWS**
Dr.-Ing. Michael Kreutzer		Integrated course	3

<table>
<tr><td colspan="6">Module name
Secure Mobile Systems</td></tr>
<tr><td>Module nr.
20-00-0583</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 2. Semester</td></tr>
<tr><td colspan="3">Language
German/English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Matthias Hollick</td></tr>
</table>

1	**Teaching content** The integrated course Secure Mobile Systems covers the topic area of security in wireless and mobile networks and communication systems. Fundamental topics will be enriched by current research. Course contents: - Security analysis and modelling of security threats in mobile and wireless systems - Selected attacks and security mechanisms specific to mobile and wireless systems - Security in wireless sensor networks - Security in wireless mesh networks - Threats against privacy and privacy-preserving mechanisms in mobile and wireless systems - Security in cellular networks (GSM, UMTS, LTE) - Security on the physical layer in mobile and wireless systems - Selected research topisc in mobile and wireless systems
2	**Learning objectives** After successfully attending the course, students have a specialized knowledge in the domain of security with emphasis on mobile, distributed, wireless communication networks. Students are able to apply and transfer the most important fundamentals from IT security, cryptography and traditional network security to the field of mobile systems. Students obtain a thorough understanding of security mechanisms on the different network layers (application layer, transport layer, network layer, link layer, physical layer). As a result, they are able to thoroughly discuss the characteristics and principles in the area of mobile system security and exhibit detailed theoretical and practical knowledge in this field.
3	**Recommended prerequisites for participation** Grundlagen der Netzsicherheit und der Mobilen Netze
4	**Form of examination** Course related exam: • [20-00-0583-vl] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0583-vl] (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 Can 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** Levente Buttyan, Jean-Pierre Hubaux: Security and Cooperation in Wireless Networks, Cambridge University Press, 2008, ISBN: 978-0-521-87371-0 (book is available online for download). Ausgewählte Buchkapitel und ausgewählte wissenschaftliche Veröffentlichungen.

Courses

Course nr.	**Course name**		
20-00-0583-vl	Secure Mobile Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Matthias Hollick		Lecture	2

Module name Lab Exercise on Secure Mobile Networking					
Module nr. 20-00-0552	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Karsten Weihe		

1	**Teaching content** The Lab Exercise on Secure Mobile Networking covers the applied software development as well as hardware-software development. Topic areas covered are communication networks, IT security, mobile networks and wireless communications as well as the combination of these. Goal is the solving of a given problem by implementation in software or hardware/software in a team. Course contents: - Solving of a problem in the area of communication networks, IT security, mobile networks and wireless communications - Survey on solution alternatives and discussion of pros and cons - Conception of a software architecture or a combined hardware-software architecture - Software/hardware design for the target platform - Prototypical realization on the target platform - Evaluation of the system with respect to performance aspects - Documentation of the implemented solution
2	**Learning objectives** After successfully attending the course, students have aquired the ability to solve problems in the area of secure mobile networking using software technology. The students have gained insight into the design/implementation of complex protocols or applications in one/multiple of the areas of communication networks, IT security, mobile netwokrs and wireless communications. They are able to implement the chosen protocols and application, and to test the functionality as well as to evaluate the performance. Students are able to document the developed software artefacts and to present the project progress and outcomes.
3	**Recommended prerequisites for participation** Successfull participation in an lecture of SEEMOO.
4	**Form of examination** Course related exam: • [20-00-0552-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0552-pr] (Study achievement, 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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**

9	**References** Will be given in lab.			
Courses				
	Course nr. 20-00-0552-pr	**Course name** Secure Mobile Networking Lab		
	Instructor Prof. Dr.-Ing. Matthias Hollick		**Type** Internship	**SWS** 4

Module name					
Project on Secure Mobile Networking					
Module nr. 20-00-0553	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Karsten Weihe		

1	**Teaching content** The Project on Secure Mobile Networking covers the applied software development as well as hardware-software development. Topic areas covered are communication networks, IT security, mobile netwokrs and wireless communications as well as the combination of these. Goal is to independently carry out a development project in a team. Course contents: - Independent solving of a development project in the area of communication networks, IT security, mobile netwokrs and wireless communications - Project planning and project management - Survey on solution alternatives and discussion of pros and cons - Conception of a software architecture or a combined hardware-software architecture - Software/hardware design for the target platform - Prototypical realization on the target platform - Evaluation of the system with respect to performance aspects - Documentation of the implemented solution as well as extensive documentation of the project management
2	**Learning objectives** After successfully attending the course, students have aquired the ability to solve complex problems in the area of secure mobile networking using software technology. To this end, the students are able to independently define, manage and carrry out a project. The students have gained insight into the design/implementation of complex protocols or applications in one/multiple of the areas of communication networks, IT security, mobile netwokrs and wireless communications. They are able to implement the chosen protocols and application, and to test the functionality as well as to evaluate the performance. The students are able to document the project planning and management, the developed software artefacts and to present the project progress and outcomes.
3	**Recommended prerequisites for participation** Successfull participation of an lecture of SEEMOO.
4	**Form of examination** Course related exam: • [20-00-0553-pp] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0553-pp] (Study achievement, 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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be given in project.

Courses

Course nr.	Course name		
20-00-0553-pp	Secure Mobile Networking Project		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Matthias Hollick		Internship	6

Module name					
Introduction to Cryptography					
Module nr. 20-00-0085	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Dr.-Ing. Michael Kreutzer		

1 Teaching content

Mathematical basic principles:

- Calculations in congruence and residue class rings

Basic principles of encryption:

- Symmetric vs. asymmetric cryptosystems
- Block and stream ciphers, AES, DES
- Cryptanalysis
- Probability and perfect security
- Public-key encryption
- RSA, Diffie-Hellman, ElGamal
- Factoring large numbers
- Discrete logarithms
- Cryptographic hash functions
- Digital signatures
- Identification

2 Learning objectives

After successful completion of the module students

- understood the mathematical foundations of cryptography such as calculations in congruence and residue class rings, factoring large numbers, probability theory and perfect security
- understood the principles of public and secret key encryption and relevant schemes including their security and efficiency
- understood the principles of digital signatures and the relevant schemes including their security and efficiency

3 Recommended prerequisites for participation

Recommended:

- Linear Algebra for Computer Science
- Funktionale und Objektorientierte Programmierkonzepte

4 Form of examination

Course related exam:

- [20-00-0085-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:

- [20-00-0085-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

<table>
<tr><td>7</td><td>Usability of the module
B. Sc. Informatik
M. Sc. Informatik
M. Sc. IT Sicherheit
M.Sc. IT Security

May be used in other degree programs.</td></tr>
<tr><td>8</td><td>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.</td></tr>
<tr><td>9</td><td>References
Johannes Buchmann: Einführung in die Kryptographie, 5. Auflage, Springer-Verlag, 2010, 278 p. ISBN: 978-3-642-11185-3
Johannes Buchmann: Cryptographic Protocols. Vorlesungsskript (u.a. Undeniable, Fail-Stop und Blind Signatures)
Neal Koblitz:A Course in Number Theory and Cryptography, Springer Verlag, 1994
Alfred J. Menezes, Paul C. van Oorschot, Scot A. Vanstone: Handbook of Applied Cryptography, CRC Press, 1997 (erhältlich als PDF)
Bruce Schneier: Applied Cryptography, John Wiley & Sons, Inc., 1994
Douglas R. Stinson: Cryptography - Theory and Practice, CRC Press, 1995
Gustavus J. Simmons: Contemporary Cryptology - The Science of Information Integrity, IEEE Press, 1992</td></tr>
</table>

<table>
<tr><td colspan="4">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
20-00-0085-iv</td><td colspan="2">Course name
Introduction to Cryptography</td></tr>
<tr><td>Instructor</td><td>Type
Integrated course</td><td>SWS
4</td></tr>
</table>

Module name Crisis, Security and Peace Technologies					
Module nr. 20-00-1019	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Stefan Katzenbeisser		

1	**Teaching content** During the course of this seminar advanced theories and subjects from the field of "Science and Technology for Peace and Security" (PEASEC) will be developed. Based on the introduction and repetition of the princi-ples in scientific research, contemporary project topics which are related to PEASEC research will be offered by us and addressed by students applying scientific methods. During the semester scientific articles ("pa-pers") will be developed and presented. As usual in scientific work, students will constructively review each other's work in a peer-review process. Subsequently, the papers will be revised for the finalization and sub-mission. EXEMPLARY THEMATIC AREAS - Safety-critical human-computer interaction, social media and collaborative technologies in conflict and crisis situations, usable security and privacy - Information technology for peace and security, information warfare, manipulation of opinions, fake news, cyber war, cyber peace, dual-use in computer science, conscientious digitalization, computer science and society - Resilient IT-based (critical) infrastructures, particularly communication, agriculture, energy Topics for the current semester are available at www.peasec.de/lehre PROCEDURE: - Technical introduction including the presentation and assignment of topics - Writing and submitting a short exposé - Methodological lecture - Short presentation of the own topic and constructive feedback - Submission of a first complete version of the paper - Assessment within a students' peer-review process - Final submission of the paper - Grading A mandatory introduction („kick-off") is the first date, the mandatory methodological lecture is the second date. The assignment of topics and formation of groups will take place collaboratively during the kickoff and, if necessary, in the following week.
2	**Learning objectives** - Autonomous familiarization with a topic in the field of peace, conflict and security research from the per-spective of computer science - Further autonomous literature research, interpretation and classification - Preparation and presentation of the topic to a heterogenous audience and subsequent expert discussion - Writing a scientific article - Assessment of scientific articles („peer-review") with constructive feedback - Knowledge of the procedures of academic research and publication
3	**Recommended prerequisites for participation** Principles in one of the subjects: Computer Science, IT-Security, Human-Computer-Interaction or Peace and Conflict Studies; basic knowledge in the topics of PEASEC
4	**Form of examination** Course related exam: • [20-00-1019-se] (Study achievement, Oral/written examination, Default RS)

<table>
<tr><td>5</td><td colspan="4">Prerequisite for the award of credit points
Pass exam (100%)</td></tr>
<tr><td>6</td><td colspan="4">Grading
Course related exam:
• [20-00-1019-se] (Study achievement, Oral/written examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td colspan="4">Usability of the module
B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.</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
Reuter, C. (2018) Sicherheitskritische Mensch-Computer-Interaktion: Interaktive Technologien und Soziale Medien im Krisen- und Sicherheitsmanagement, 660 S., Wiesbaden: Springer Vieweg - im Druck
Altmann, J., Bernhardt, U., Nixdorff, K., Ruhmann, I., & Wöhrle, D. (2016) Naturwissenschaft - Rüstung - Frieden - Basiswissen für die Friedensforschung (Vol. 49), Wiesbaden: Springer Vieweg.
Flick, U. (2015) Introducing Research Methodology. Sage Publications Ltd
Further literature will be provided in the course dependent on the selected topic.</td></tr>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
20-00-1019-se</td><td colspan="3">Course name
Crisis, Security and Peace Technologies</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. techn. Stefan Katzenbeisser</td><td>Type
Seminar</td><td>SWS
2</td></tr>
</table>

Module name					
Information Technology for Peace and Security					
Module nr. 20-00-1026	**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. techn. Stefan Katzenbeisser		

1	**Teaching content** Technological and scientific progress, especially the rapid development in information technology (IT), plays a crucial role regarding questions of peace and security. This course addresses the significance, potentials and challenges of IT for peace and security. For this purpose, the course offers an introduction to peace, conflict, and security research, thereby focusing on natural-science, technical and computer science perspec-tives. It thereby sheds light on cyber conflicts, war and peace, cyber arms control, cyber attribution and infra-structures as well as culture and interaction before an outlook is given. CONTENT: - Introduction to Natural-Science/Technical Peace Research and IT Perspectives of Peace, Conflict, and Secu-rity Research - Cyber War, Espionage, Defense, Darknets, Critical Infrastructures, Cultural Violence - Cyber Peace, Dual-Use, Confidence and Security Building Measures, Arms Control, Unmanned Systems, Verification, Attribution STRUCTURE: - Part I: Introduction und Foundations (Introduction and Overview, IT in Peace, Conflict and Security Research (Natural-Science/Technical Peace Research)) - Part II: Cyber War and Conflict (Information Warfare, Cyber Espionage and Cyber Defense, Darknets as Tools for Cyber Warfare) - Part III: Cyber Peace (From Cyberwar to Cyberpeace, Dual-Use and Dilemmas of Cybersecurity, Confidence and Security Building Measures for Cyber Forces) - Part IV: Cyber Arms Control (Arms Control and its Applicability to Cyberspace, Unmanned Systems: The Robotic Revolution, Verification in Cyberspace) - Part V: Cyber Attribution and Infrastructures (Attribution of Cyber Attacks, Resilient Critical Infrastructures, Security of Critical Information Infrastructures) - Part VI: Social Interaction (Safety and Security, Cultural Violence, Social Media and ICT Usage in Conflict Areas) - Part VII: Outlook (The Future of IT in Peace and Security) Characteristics for the current semester are available at www.peasec.de/lehre
2	**Learning objectives** - Knowledge of basics of computer science for peace, conflict and security research - Assessment of IT to promote or prevent peace and security - Knowledge in the design and development of IT for peace
3	**Recommended prerequisites for participation** Principles in one of the subjects: Computer Science, IT-Security, Human-Computer-Interaction or Peace and Conflict Studies
4	**Form of examination** Course related exam: • [20-00-1026-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)

6	**Grading** Course related exam: • [20-00-1026-iv] (Technical examination, 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**

Courses

Course nr.	**Course name**		
20-00-1026-iv	Information Technology for Peace and Security		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Stefan Katzenbeisser		Integrated course	4

Module name Computer Security					
Module nr. 20-00-0018	**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

Part I: Cryptography
- Background in mathematics for cryptography
- Security objectives: Confidentiality, Integrity, Authenticity
- Symmetric and asymmetric cryptography
- Hash functions and digital signatures
- Protocols for key distribution

Part II: IT-Security and Dependability
- Basic concepts of IT security
- Authentication
- Access control models and mechanisms
- Basic concepts of network security
- Basic concepts of software security
- Basic concepts of web security
- - Dependable systems: error tolerance, redundancy, availability

2 Learning objectives

After successfully attending the course, students are familiar with the basic concepts, methods and models in the areas of cryptography and computer security. They understand the most important methods that allow to secure software and hardware systems against attackers and are able to apply this knowledge to concrete application scenarios.

3 Recommended prerequisites for participation

4 Form of examination

Course related exam:
- [20-00-0018-iv] (Technical examination, Oral/written examination, Default RS)

Written Exam (90 min.)

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:
- [20-00-0018-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B. Sc. Informatik
B.Sc. Wirtschaftsinformatik
Lehramt an Gymnasien - Fach 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

- M. Bishop, Computer Security: Art and Science, Addison Wesley, 2018
- P.C.van Oorschot: Computer Security and the Internet, Springer, 2021
- J. Katz, Y. Lindell: Introduction to Modern Cryptography, Chapman & Hall, 2020

Courses

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

Module name					
Formal Methods for Information Security					
Module nr. 20-00-0362	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Heiko Mantel		

1	**Teaching content** - formal modeling of security-critical systems in predicate logic - theoretical foundations of access control and information-flow control - formal modeling of security properties in predicate logic - distinction between qualitative and quantitative security properties - decidability and complexity results for security properties - verification of security guarantees in distributed systems - impact of stepwise composition and refinement on security guarantees - formal languages for specifying security policies and their semantics - certification of security-critical systems
2	**Learning objectives** After successfully participating in this course, students know relevant formal security models and analysis techniques. They understand the fundamental differences between various classes of security properties and the interplay between stepwise software development and security guarantees. They are able to model systems and security requirements formally and to analyze security aspects rigorously based on formal specifications.
3	**Recommended prerequisites for participation** Knowledge within Computer Science and Mathematics according 1-4 semester of B.Sc. Computer Science.
4	**Form of examination** Course related exam: • [20-00-0362-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0362-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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References**

	- M. Bishop: Computer Security, Addison-Wesley - J. Biskup: Security in Computing Systems, Springer-Verlag - C. P. Pfleeger, S. L. Pfleeger: Security in Computing, Prentice Hall - D. Denning: Cryptography and Data Security, Addison Wesley Literature recommendations will be updatet regularly.

Courses

Course nr.	Course name		
20-00-0362-iv	Formal Methods for Information Security		
Instructor		**Type**	**SWS**
		Integrated course	6

Module name Network Security					
Module nr. 20-00-0512	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Dr.-Ing. Michael Kreutzer		

1 Teaching content

The integrated course Network Security covers the principles and practice of computer and telecommunication network security with particular emphasis on Internet security. After transferring the fundamentals of IT security and cryptography to the networking domain, we follow a top-down approach to network security. Starting with the application layer, the course provides a detailed discussion of network security principles and protocols. In addition to well known mechanisms, selected recent developments in the area of network security will be examined.

Course contents:
- Network security: introduction, motivation, and challenges
- Fundamentals: a reference model for network security, security standards for networks and the Internet, security threats, attacks, services, and mechanisms
- Cryptographic foundations for networking security: symmetric crypto and its use in networks, public-key crypto and its use in networks, support functions to implement network security
- Application layer security
- Transport layer security
- Network layer security
- Link layer security
- Physical layer security and physical security
- Operational network security: firewalls, intrusion detection systems
- Selected topics in network security

2 Learning objectives

After successfully attending the course, students have aquired an in-deep knowledge in the domain of communication network security with emphasis on Internet security. Students are able to apply and transfer the most important fundamentals from IT security and cryptography to the field of communication networks. Students are able to distinguish the most important basic techniques for securing communication networks. They have a thorough understanding of security mechanisms on the different network layers (application layer, transport layer, network layer, link layer, physical layer). As a result, they are able to thoroughly discuss the characteristics and principles in the area of network security and exhibit detailed theoretical and practical knowledge in this field. Additionally, students are able to describe recent developments in the area of network security (e.g. peer-to-peer security, mobile network security, etc.). The exercise deepens the theoretical foundations by means of exercises, which consist of literature, calculation as well as practical implementation/application examples.

3 Recommended prerequisites for participation

Knowledge in the area IT Security, Introduction to Cryptography and Communication Networks

4 Form of examination

Course related exam:
- [20-00-0512-iv] (Technical examination, Oral/written examination, Default RS)

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:
- [20-00-0512-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 Can 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** Charlie Kaufman, Radia Perlman, Mike Speciner: Network Security - Private Communication in a Public World, 2nd Edition, Prentice Hall, 2002, ISBN: 978-0-14-046019-6; additional texts may be announced

Courses

Course nr.	Course name		
20-00-0512-iv	Network Security		
Instructor		**Type**	**SWS**
Dr.-Ing. Michael Kreutzer		Integrated course	4

Module name Embedded System Security					
Module nr. 20-00-0581	**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. Ahmad-Reza Sadeghi		

1	**Teaching content** Trusted Computing - Authenticated Boot - Binding and Sealing - Integrity Measurement and Attestation - Direct Anonymous Attestation - Trusted Platform Modules (TPM/MTM) - On-board Credentials Mobile Security with focus on smartphones - Security Architectures - Selected Access Control and Permission Model Aspects - Context-based Security Policies - Selected Modern Attack Techniques Hardware-based Cryptography - Hardware-assisted Cryptographic Protocols - Introduction to Physical Unclonable Functions (PUFs)
2	**Learning objectives** During this lecture students acquire detailed knowledge of selected aspects in system security (based on hardware and software).
3	**Recommended prerequisites for participation** Grundlagen der Kryptographie
4	**Form of examination** Course related exam: • [20-00-0581-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0581-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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References**

	- Challener, David, VanDoorn, Leendert, Safford, David, Yoder, Kent, Catherman, Ryan ""A Practical Guide to Trusted Computing"", IBM Press, 2007 - Smith, Sean W. ""Trusted Computing Platforms: Design and Applications"", Springer Verlag, 2005

Courses

Course nr.	Course name		
20-00-0581-iv	Embedded System Security		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ahmad-Reza Sadeghi		Integrated course	4

Module name					
Public Key Infrastructures					
Module nr.	**Credit points**	**Workload**	**Self-study**	**Module duration**	**Module cycle**
20-00-0063	6 CP	180 h	120 h	1 Term	Every 2. Semester
Language			**Module owner**		
German			Dr.-Ing. Michael Kreutzer		

1	Teaching content

1. Security Goals
    1. Confidentiality
    2. Integrity
    3. Authenticity of Data
    4. Entity Authentication/Identification
    5. Non-repudiation
    6. Availability
    7. Other Goals
2. Public Key Cryptography
    1. Encryption (symmetric, assymetric, hybrid, cryptosystems, key exchange, performance, security, computational problems)
    2. Cryptographic Hash Functions
    3. Message Authentication Codes
    4. Digital Signatures (performance, standards)
3. Certificates
    1. X.509 Public Key Certificates (properties, content, extensions)
    2. PGP
    3. WAP Certificates
    4. Attribute Certificates
4. Trust Models
    1. Direct Trust (fingerprints, examples of)
    2. Web of Trust (key legitimacy, owner trust, trusted introducers)
    3. Use of PGP
    4. Hierarchical Trust (trusted list, common root, cross-certification, bridge)
5. Private Keys
    1. Software Personal Security Environments (PKCS#12, Java Keystore, application specific)
    2. Hardware Personal Security Environments (smart cards, hardware security modules, java cards)
    3. Private Key Life-cycle
6. Revocation
    1. Revocation (reaons for, requirements, criteria)
    2. Certificate Revocation Lists
    3. Delta Certificate Revocation Lists
    4. Other Certificate Revocation Lists (over-issued, indirect, redirect)
    5. OCSP
    6. Other Revocation Mechanisms (NOVOMODO)
7. Policies
    1. Certificate Life-cycle
    2. Certificate Policy and Certification Practice Statement
    3. Set of Provisions
8. Validity Models
    1. Shell Model
    2. Modified Shell Model
    3. Chain Model
9. Certification Path Validation

10. Trust Center
    1. Registration Authority (registration protocols, proof-of-possession, extended validation certificates)
    2. Certification Authority
    3. Certificate Management Authority
11. Certification Paths and Protocols
    1. Construction
    2. LDAP and other methods
    3. SCVP

2	**Learning objectives** After completion of the module Public Key Infrastructures, the students are able to • understand the IT security goals and the cryptographic primitives to realize these goals. • understand and explain the foundations of Public Key Infrastructures, in particular the different components (e.g., private keys, certificates, policies), actors (e.g., Trust centers, key owners) and processes (e.g., certificate request, certificate issuance, validation of certificates, revocation). • understand, explain and apply the underlying theoretical models (e.g., trust models, validity models. • use Public Key Infrastructures in practice (e.g., for Email signing and encryption, validation of the authenticity of web sites).
3	**Recommended prerequisites for participation**
4	**Form of examination** Course related exam: • [20-00-0063-iv] (Technical examination, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0063-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B. Sc. Informatik M. Sc. Informatik M. Sc. IT Sicherheit May be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References** • J. Buchmann, E. Karatsiolis, and A. Wiesmaier. ""Introduction to Public Key Infrastructures"", Springer-Verlag Berlin Heidelberg, 2013. ISBN: 978-3-642-40656-0 (Print) 978-3-642-40657-7 (Online) • J. Buchmann, ""Einführung in die Kryptographie"", ISBN 3-540-41283-2 • C. Adams / S. Lloyd, ""Understanding Public-Key Infrastructure"", ISBN 1-57870-166-X • Tom Austin, ""PKI / A Wiley Tech Brief"", ISBN 0-471-35380-9 • R. Housley / T. Polk, ""Planning for PKI"", ISBN 0-471-39702-4 • A. Nash / W. Duane / C. Joseph/ D. Brink, ""PKI Implementing and Managing E-Security"", ISBN 0-007-213123-3 • Henk C.A. van Tilborg, ""Encyclopedia of Cryptography and Security"", ISBN-13: 978-0387234731
Courses	

	Course nr.	Course name		
	20-00-0063-iv	Public Key Infrastructures		
	Instructor		**Type** Integrated course	**SWS** 4

Module name Security of Critical Infrastructures					
Module nr. 20-00-0720	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Dr.-Ing. Michael Kreutzer		

1 Teaching content

Critical infrastructures are organisations or institutions of major importance to the state community, their failure or impairment would result in long-term supply shortages, significant disruption to public security or other dramatic consequences (BMI, 2009).

The lecture focuses on different critical infrastructures and their security challenges. After an introduction into some basics, speakers from research institutions, companies, authorities or operators of critical infrastructures are lecturing on specific facets of the topic. A self-study of selected articles complements the lectures.

In the past years, speakers from the German Bundestag, the Federal Office of Civil Protection and Disaster Assistance (BBK), the Federal Office for Information Security (BSI), the German Federal Agency for Technical Relief (BBK), the Hessen Cyber Competence Center (Hessen 3C), Siemens AG, Deutsche Bahn, Deutsche Börse, German Air Traffic Control, as well as from universities and research institutions have given lectures.

2 Learning objectives

After successfully attending the course, students are familiar with the most important IT security problems in critical infrastructures. They understand techniques that allow to secure critical infrastrures and are able to apply them in different sectors (such as the smart grid, the transportation or the telecommunications sectors).

3 Recommended prerequisites for participation

Computersystemsicherheit

4 Form of examination

Course related exam:

- [20-00-0720-iv] (Technical examination, Oral/written examination, Default RS)

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:

- [20-00-0720-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

Can be used in other degree programs.

8 Grade bonus compliant to §25 (2)

9 References

	Will be given in lecture.

Courses

Course nr.	Course name		
20-00-0720-iv	Critical Infrastructure Protection		
Instructor		**Type**	**SWS**
Dr.-Ing. Michael Kreutzer		Integrated course	2

Module name					
Seminar on Networking, Security, Mobility, and Wireless Communications					
Module nr. 20-00-0582	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Matthias Hollick		

1	**Teaching content** The Seminar on Networking, Security, Mobility, and Wireless Communications covers current research in the given topic areas. Under supervision of the tutors, the seminar imcludes studying, critically analyzing and discussing, summarizing, and presenting selected research articles. Deliverables are a short presentation, a final presentation, and a seminar paper. Course contents: - Indepentent exploration of a topic in the area of networking, security, mobility, and wireless communications (typically in english) - Own, enhanced literature study, gudided by tutor - Interpretation and classification of the literature study, gudided by tutor - Preparation of an introductory talk as well as a final talk including presentation slides, gudided by tutor - Presentation of both talks for a heterogenous audience (experts/non-experts) - Technical discussion after the talks - Feedback to the speakers and the talks (including presentation skills) and technical content
2	**Learning objectives** After successfully attending the course, students are able to work in a scientific manner under guidance. They know the fundamental techniques for scientific literature work and can apply them to a well-defined topic area. They have aquired intermediate knowledge on selected mechanisms, methodologies as well as applications for the investigated topic area. Students can present this aquired knowledge to a heterogeneous audience and explain the technical details of the investigated topic.
3	**Recommended prerequisites for participation** Successfull participation in a lecture of SEEMOO.
4	**Form of examination** Course related exam: • [20-00-0582-se] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0582-se] (Study achievement, 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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**

9	**References** Depending on topic.

Courses

Course nr.	Course name		
20-00-0582-se	Seminar on Networking, Security, Mobility, and Wireless Communications		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Matthias Hollick		Seminar	2

Module name					
Security in Multimedia Systems and Applications					
Module nr. 20-00-0093	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Dr.-Ing. Michael Kreutzer		

1	**Teaching content** The students will gain an insight into the challenges of multimedia security and the established solution approaches. These include concepts such as media integrity, confidentiality and authenticity. The students already know the procedures used in digital watermarking, robust hashing, partial encryption, multimedia forensics and DRM. Choosing the appropriate solution from a full panoply of solution mechanisms they will be able to respond optimally to the multimedia security challenges depending on the respective requirements. • Partial encoding procedures for video and audio to ensure confidentiality and authenticity • Digital watermarks for images and audio - areas of application, methods and procedures • Digital Rights Management and Copyright protection procedures • Visual cryptography Besides discussing different algorithms, i.e. their possibilities, limitations and weaknesses, the commercial and societal aspects of protective measures will also be part of the lecture.
2	**Learning objectives** After successful completion of the module students got an overview of the challenges posed by multimedia security as well as known solutions. This includes concepts of digital watermarks, robust hashes, partial encryption, multimedia forensics, and DRM. The students are able to address challenges of multimedia security by applying appropriate solutions.
3	**Recommended prerequisites for participation** Recommended: Basic knowledge in Multimedia-Formats and IT Security.
4	**Form of examination** Course related exam: • [20-00-0093-vl] (Technical examination, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0093-vl] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B. Sc. Informatik M. Sc. Informatik M. Sc. IT Sicherheit M.Sc. IT Security 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** • Steinmetz: Multimedia-Technologie. Grundlagen, Komponenten und Systeme, ISBN: 3540673326, Springer, Heidelberg, 2000 • Dittmann: Digitale Wasserzeichen, Springer Verlag, ISBN 3 - 540 - 66661 - 3, 2000 • Cox, Miller, Bloom: Digital Watermarking, Academic Press, San Diego, USA, ISBN 1-55860-714-5, 2002 • und spezifische Veröffentlichungen aus Tagungsbänden"

Courses

Course nr.	Course name		
20-00-0093-vl	Security in Multimedia Systems and Applications		
Instructor		**Type**	**SWS**
		Integrated course	2

Module name Safty of railway signaling systems					
Module nr. 20-00-0461	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Dr.-Ing. Michael Kreutzer		

1	**Teaching content**
2	**Learning objectives**
3	**Recommended prerequisites for participation**
4	**Form of examination** Course related exam: • [20-00-0461-se] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0461-se] (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**		
20-00-0461-se	Sicherheitskonzepte im Eisenbahnbetrieb		
Instructor		**Type** Seminar	**SWS** 2

<table>
<tr><td colspan="7">Module name
Real World Cryptography</td></tr>
<tr><td colspan="2">Module nr.
20-00-0993</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="4">Language
German</td><td colspan="3">Module owner
Prof. Dr. techn. Stefan Katzenbeisser</td></tr>
<tr><td>1</td><td colspan="6">Teaching content
Key derivation, key exchange, secure communication, credentials, crypto currencies (TLS, SSH, IPSec, Bitcoin,...).</td></tr>
<tr><td>2</td><td colspan="6">Learning objectives
After successful completion the participants understand the design choices and security guarantees of real-world cryptographic protocols, used in our daily lives. They learn to judge the significance and limitations of security models and security proofs for practical purposes.</td></tr>
<tr><td>3</td><td colspan="6">Recommended prerequisites for participation
Einführung in die Kryptographie</td></tr>
<tr><td>4</td><td colspan="6">Form of examination
Course related exam:
• [20-00-0993-iv] (Technical examination, Oral/written examination, Default RS)</td></tr>
<tr><td>5</td><td colspan="6">Prerequisite for the award of credit points
Pass exam (100%)</td></tr>
<tr><td>6</td><td colspan="6">Grading
Course related exam:
• [20-00-0993-iv] (Technical examination, Oral/written examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td colspan="6">Usability of the module
B.Sc. Informatik
M.Sc. Informatik
May be used in other degree progams.</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</td></tr>
<tr><td colspan="7">Courses</td></tr>
<tr><td rowspan="2"></td><td colspan="2">Course nr.
20-00-0993-iv</td><td colspan="4">Course name
Real World Cryptography</td></tr>
<tr><td colspan="4">Instructor
Prof. Dr. techn. Stefan Katzenbeisser</td><td>Type
Integrated course</td><td>SWS
4</td></tr>
</table>

Module name Practical Lab on System and IoT Security					
Module nr. 20-00-0615	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Dr.-Ing. Michael Kreutzer		

1	**Teaching content** In this practical course, the students deal with different aspects of smartphone security. The project tasks specifically target the open-source Android OS and comprise the following areas: - Design and implementation of selected software attacks (ethical hacking) - Design and implemenation of secure user apps - Modifications of the Android Middleware and Kernel to build security architectures - System programming in general
2	**Learning objectives** After successfully completing this lab students will have gained knowledge and hands-on expercience with security mechanisms in modern smartphone operating systems. Futhermore they gain experience in system programming in general.
3	**Recommended prerequisites for participation** - Basics operating systems - Knowledge in C++ and Java
4	**Form of examination** Course related exam: • [20-00-0615-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0615-pr] (Study achievement, 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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be given in lab.

Courses

Course nr.	**Course name**		
20-00-0615-pr	Practical Lab on System and IoT Security		
Instructor		**Type**	**SWS**
		Internship	4

Module name Cybersecurity Lab					
Module nr. 20-00-1018	**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. techn. Stefan Katzenbeisser		

1	**Teaching content** In this lab we will learn the basic and advanced aspects of network security. We will review the foundational protocols, such as BGP and DNS, infrastructure modules, such as routers, switches and firewalls, and will also discuss applications security. We will discuss and demonstrate attacks and defences. Each of the students will receive a specific topic on which they will work during the semester, and on which they will be guided.
2	**Learning objectives** At the end of the course the students will acquire a good knowledge in Network security, and in particular in topics on which they will prepare projects. The grade is based on the quality of the submitted project.
3	**Recommended prerequisites for participation** The students should have a background in networking and in operating systems - these are prerequisite courses.
4	**Form of examination** Course related exam: • [20-00-1018-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1018-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**

Courses

Course nr.	Course name		
20-00-1018-pr	Cybersecurity Lab		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Stefan Katzenbeisser		Internship	4

Module name					
Protection in Networked Systems - Trust, Resilience, and Privacy					
Module nr. 20-00-0969	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. techn. Stefan Katzenbeisser		

1	**Teaching content** - Protection in Networked Systems: background, motivation, challenges - Trust (Computational Trust): models and mechanisms - Trust (Computational Trust): application in PKI, Cloud Computing, Reputation Systems, and Web Services - Trust: regret management and device comfort - Privacy: privacy definitions, models, data anonymity, communication anonymity - Privacy & Trust: privacy-preserving trust models, mechanisms, and application to IDM - Security & Economics - Resilience: models, network intrusion detection systems, collaborative intrusion detection systems, honeypots - Resilient networks
2	**Learning objectives** The integrated lecture Protection in Networked Systems ? Trust, Resilience, and Privacy covers the topics of computational trust, resilient and anonymous networks, and collaborative defense mechanisms. By attending this course, the students will be able to understand the problems and solutions in the context of networked systems. The course content will consider the concept of End-to-End systems emphasizing on users, devices, networks, and applications or services.
3	**Recommended prerequisites for participation** - Trust and Reputation for Service-Oriented Environments: Technologies For Building Business Intelligence And Consumer Confidence, Elizabeth Chang, Tharam Dillon, and Farookh K. Hussain, 374 pages, 2006. ISBN: 978-0-470-01547-6 - On anonymity in an electronic society: A survey of anonymous communication systems, Matthew Edman and Bülent Yener, ACM Computing Surveys, Vol. 42, Issue 1, 2009. - Taxonomy and Survey of Collaborative Intrusion Detection, Emmanouil Vasilomanolakis, Shankar Karuppayah, Max Mühlhäuser, Mathias Fischer, ACM Computing Surveys, Vol. 47 Issue 4, 2015. - Selected book chapters and scientific publications
4	**Form of examination** Course related exam: • [20-00-0969-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0969-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References**
Courses	

<table>
<tr><td rowspan="2"></td><td>Course nr.
20-00-0969-iv</td><td colspan="3">Course name
Protection in Networked Systems - Trust, Resilience, and Privacy</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. techn. Stefan Katzenbeisser</td><td>Type
Integrated course</td><td>SWS
2</td></tr>
</table>

Module name Lab Peace-, Security and Crisis Informatics					
Module nr. 20-00-1020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Stefan Katzenbeisser		

1	**Teaching content** The lab course offers development projects relevant to the current research of the research group “Science and Technology for Peace and Security” (PEASEC). In addition to a broad overview, students will gain insight in a specific area of development. These topics are linked to the specializations of the members of the re-search group and provide the students with technical and scientific insight. The topics will be worked on in small groups. Examples for topics are available at www.peasec.de/lehre
2	**Learning objectives** Acquiring the qualification for solving a practical task in a team or by oneself and presenting the results, such as: - Resolution of an issue in the domain of peace, security and crisis informatics - Requirements engineering and empirical studies - Research of solution alternatives and assessment of their (dis)advantages - Design, prototypical implementation and maintenance of innovative applications - Evaluation of existing applications with regard to different assessment criteria - Documentation of the developed solution
3	**Recommended prerequisites for participation** Foundations of Computer Science/Functional and Object-oriented Programming Concepts
4	**Form of examination** Course related exam: • [20-00-1020-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1020-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** Reuter, C. (2018) Sicherheitskritische Mensch-Computer-Interaktion: Interaktive Technologien und Soziale Medien im Krisen- und Sicherheitsmanagement, 660 S., Wiesbaden: Springer Vieweg - im Druck Altmann, J., Bernhardt, U., Nixdorff, K., Ruhmann, I., & Wöhrle, D. (2016). Naturwissenschaft - Rüstung - Frieden - Basiswissen für die Friedensforschung (Vol. 49), Wiesbaden: Springer Vieweg. Further literature will be provided in the course dependent on the selected topic.
Courses	

	Course nr.	Course name		
	20-00-1020-pr	Lab Peace-, Security and Crisis Informatics		
	Instructor		**Type**	**SWS**
	Prof. Dr. techn. Stefan Katzenbeisser		Internship	4

Module name					
System and IoT Security					
Module nr. 20-00-0652	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Ahmad-Reza Sadeghi		

1	**Teaching content** In this seminar different security aspects of mobile devices (especially smartphone) will be analyzed and discussed. Students will process, summarize and evaluate a number of current scientific publications for a certain topic in form of an essay. Additionally, each student will present his work in front of the group at the end of the semester. Possible topics include: - Security models of current smartphone operating systems (e.g. Android, iOS, Windows Phone, MeeGo, Symbian, RIM) - Security analysis and comparison of current app store models - Usage of mobile devices in enterprises - Security extensions for Android - Kernel security - Application security (e.g. mobile malware and runtime attacks) - Privacy aspects in mobile devices - Security of mobile networks
2	**Learning objectives** This seminar covers several topics in the area of mobile security with the focus on smartphone security. Through this course students will gain detailed knowledge on the security and privacy aspects of mobile operating systems, devices, infrastructures and end-user applications. Moreover, they learn to examine current research in this area, to dive into a scientific topic and present their results in a short paper as well as an oral presentation.
3	**Recommended prerequisites for participation** Grundlagen der Informatik
4	**Form of examination** Course related exam: • [20-00-0652-se] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0652-se] (Study achievement, 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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**

9	**References** Will be given in seminar.		
Courses			
	Course nr. 20-00-0652-se	**Course name** System and IoT Security	
	Instructor Prof. Dr.-Ing. Ahmad-Reza Sadeghi	**Type** Seminar	**SWS** 2

Module name Cryptographic Protocols					
Module nr. 20-00-1032	**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. techn. Stefan Katzenbeisser		

1	**Teaching content** Cryptographic protocols allow parties with potentially conflicting interests to jointly perform certain tasks. This course covers basic and advanced constructions for cryptographic protocols and their applications, including Commitments, Secure Coin Flipping, Zero-Knowledge Proofs, Mixnets, Anonymous Credentials, Private Information Retrieval, Secure Multiparty Computation, and Hardware-assisted Cryptographic Protocols.
2	**Learning objectives** Students know basic and advanced cryptographic protocols, can assess and compare their efficiency and security, and know their basic applications.
3	**Recommended prerequisites for participation** Basic knowledge in applied cryptography is strongly recommended, e.g., by successfully completing the course "Computer Security" or "Introduction to Cryptography".
4	**Form of examination** Course related exam: • [20-00-1032-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1032-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. Informatik M.Sc. Informatik M.Sc. IT Sicherheit
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
20-00-1032-iv	Cryptographic Protocols		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Stefan Katzenbeisser		Integrated course	4

Module name					
Protection in Infrastructures and Networks					
Module nr. 20-00-1022	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Stefan Katzenbeisser		

1	**Teaching content** The Seminar on Protection in Infrastructures and Networks is a cycle of seminars where students are given the chance to read, analyze and summarize current scientific publications. The topics are related to the areas of: - Trust - Privacy - Resilience in the domain of infrastructures and networks.
2	**Learning objectives** Students participating in the seminar will have the opportunity to learn and conduct research in the direction of these topics. Your task will be to understand state-of-the-art scientific publications in order to explain their contributions. Furthermore, you are expected to write a survey in relation to the topic assigned to you.
3	**Recommended prerequisites for participation** Basic knowledge about it-security and distributed systems. Lectures: Computersystemsicherheit (CSS) Computer-Netzwerke und verteilte Systeme (CNuvS)
4	**Form of examination** Course related exam: • [20-00-1022-se] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1022-se] (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programss
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
20-00-1022-se	Protection in Infrastructures and Networks		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Stefan Katzenbeisser		Seminar	2

Module name Lab Blockchain					
Module nr. 20-00-1031	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Stefan Katzenbeisser		

1	**Teaching content** This course is aimed at students who have attended the lecture Cryptocurrencies and want to understand and examine some aspects of this topic in more detail. It provides a platform to check novel applications based on Blockchain technology for their feasibility and usefulness. Complex cryptographic systems and ideas from the lecture Cryptocurrencies should be understood in team work and implemented in a decentralized system. The students are asked to develop a project plan and outline, which should be implemented over the course of the semester. The students get first experiences with the implementation of a more complex development project.
2	**Learning objectives** Participants of this course will learn about the technical and practical implications of distributed cryptographic systems. These include first hands-on experiences in the following areas: • Development of smart contracts and distributed applications • Communication of systems through decentral peer-to-peer networks • Development of software using cryptographic building blocks • Security and anonymity of users of cryptographic currencies • Possible attacks on smart contracts and cryptocurrencies
3	**Recommended prerequisites for participation** This course is directed at students that finished the cryptocurrencies lecture with good marks and programming skills.
4	**Form of examination** Course related exam: • [20-00-1031-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1031-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**

Courses

Course nr.	Course name		
20-00-1031-pr	Lab Blockchain		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Stefan Katzenbeisser		Internship	4

Module name					
Safety-Critical Human-Computer-Interaction					
Module nr. 20-00-1025	**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. techn. Stefan Katzenbeisser		

1	Teaching content

	This course provides a sound and practice-oriented introduction and an overview of the foundations, meth-ods, and applications of human-computer-interaction (HCI) in the context of security, emergencies, crises, disasters, war, and peace. Addressing this, interactive, mobile, ubiquitous and cooperative technologies, as well as social media, are presented. Here, classical topics such as usable (IT) security, industry 4.0, civil pro-tection, medicine, and automotive, as well as augmented reality, crowdsourcing, shitstorm management, so-cial media analytics and cyberwar all find their place. Methodologically, the spectrum from usable safety to usable security engineering is covered from analysis through design to evaluation. CONTENT: - Foundations and Methods (Usable Safety; Usable Security; Analysis, Design, Implementation, Evaluation; Law, Ethics and Culture) - Safety-critical Interactive Systems (Business Information Systems, Crisis Management Systems, Medical Engineering, Warning Systems and Assistance Systems) - Safety-critical Cooperative Systems (Social Media, Cooperative Systems, Voluntary Participation, Peace and Security) STRUCTURE: Part I: Introduction and Overview Part II: Foundations and Methods - Usable Safety (Usable Safety-Engineering of Safety-critical Interactive Systems, Usability-Engineering and User Experience of Safety-critical Systems, Quantitative Evaluation of Human-Computer-Interaction) - Usable Security (Human Factors in Security, Tools for Usable (Cyber-)Security, Usable Solutions for Data Protection) - Law, Ethics and Culture (Selected Legal Implications for Safety-critical IT, Ethical, Legal and Social Implica-tions (ELSI), International and Intercultural Aspects of Safety-critical Systems) Part III: Safety-critical Interactive Systems - Business Information Systems (Critical Infrastructures and Business Continuity Management, Safety-critical Human-Machine-Interaction in Industry 4.0, IT-Systems for Crisis Management: Requirements, Functionalities and Categories) - Crisis Management and Medical Engineering (IT-Support of Standard and Exceptional Operations of Emer-gency Services, Safety-critical Human-Machine-Interaction in Medical Technology, Warnings of the Population in Disaster Situations) - Warning Systems and Assistance Systems (Human Factors in the Development of Driver Assistance Sys-tems, From Driver Information to Driver Assistance and Autonomous Driving) Part IV: Safety-critical Cooperative Systems - Social Media (Social Media in Emergency Situations, Crises and Catastrophes, Social Media Analytics for Companies and Authorities, Corporate Shitstorm Management: Confrontations in Social Media) - Cooperative Systems for Mission Situations (Resilience through Cooperative Technologies, IT-based Pro-cess Support for Safety of Major Events, Situational Awareness in Augmented and Virtual Reality Simulation Games) - Technology for Voluntary Participation (Humanitarian Aid and Concepts of Digital Aid, Involvement of Emergent Volunteers for the Mastery of Loss Events, Mobiles Crowdsourcing for the Integration of Volun-teers) - Peace and Security (Computer Science for Peace and Security, Social Media in Political Conflict Situations) Part V: Outlook: The Future of Safety-critical Human-Computer-Interaction Details for the current semester can be found at www.peasec.de/lehre
2	**Learning objectives**

	- Understanding of safety-critical HCI and the underlying disciplines HCI as well as crisis and security management - Overview of selected basics and methods of safety-critical HCI (usable safety, usable security, analysis, design, implementation, evaluation, law, ethics, and culture) - Orientation in application domains and fields - Knowledge about safety-critical interactive systems (business information systems, crisis management sys-tems, medical engineering, warning and assistance systems) - Knowledge about safety-critical cooperative systems (social media, cooperation systems, voluntary partici-pation, peace, and security)
3	**Recommended prerequisites for participation** Principles in one of the subjects: Computer Science, IT-Security, Human-Computer-Interaction or Peace and Conflict Studies
4	**Form of examination** Course related exam: • [20-00-1025-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1025-iv] (Technical examination, 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**

Courses

Course nr.	Course name		
20-00-1025-iv	Safety-Critical Human-Computer-Interaction		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Stefan Katzenbeisser		Integrated course	4

Module name Information Security Management					
Module nr. 20-00-1123	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Ph.D. Sebastian Faust		

1 Teaching content

In the lecture, an exemplary, fictitious organization is used to demonstrate how information security is established in all processes of the organization.

The following topics are considered, among others:

- Maturity level assessment regarding information security of the organization
- Capability Maturity Model Integration (CMMI) Framework
- Establishment of a Cyber Security Strategy
- Information Security Governance
- Establishment of an Information Security Management System (ISMS) according to ISO/IEC 27001:2013 and IT-Grundschutz
- Security Awareness within the organization
- Key Performance Indicator to measure information security
- Asset Management, information networks and process analyses
- Protection requirement analyses and business impact analyses
- Qualitative and quantitative risk management
- Risk analysis, treatment and monitoring processes
- Vulnerability Management (dealing with IT vulnerabilities in own and outsourced systems)
- Business Continuity Management (BCM)
- Business Continuity Planning (BCP)
- Secure IT operations, securing operational processes
- Secure development
- Securing cloud services
- Management of service providers
- Incident Management: securing, detecting and responding to security incidents
- Audit Management
- Review of compliance and governance

2 Learning objectives

The main objective of this module is to learn how IT and information security is managed in an organization, focusing on management rather than technical or formal IT security.

- Knowledge, contents and structures of an Information Security Management System (ISMS)
- Overview of common procedures regarding information security management, e.g. ISO 27001, IT-Grundschutz, NIST Cybersecurity Framework.
- Identification and protection requirement analysis of assets in the organization
- Knowledge of common risk management procedures
- Systematic assessment of information security in the organization using metrics
- Establishment of processes relevant to information security such as vulnerability management, BCM processes, incident management and audit management

3 Recommended prerequisites for participation

Attendance of the course "Computer Security" is recommended.

4 Form of examination

	Course related exam: • [20-00-1123-vl] (Technical examination, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1123-vl] (Technical examination, 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**

Courses

Course nr.	Course name		
20-00-1123-vl	Information Security Management		
Instructor		**Type**	**SWS**
Prof. Ph.D. Sebastian Faust		Lecture	2

Module name Side-channel resilient cryptography					
Module nr. 20-00-1088	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Ph.D. Sebastian Faust		

1	**Teaching content** Cryptographic schemes are classically secure against black-box attacks, where an attacker exploits weaknesses of the underlying cryptographic algorithm. When cryptography is implemented in practice, so-called side-channel attacks are a further threat to their security. Most of cryptography can be broken by side-channel attacks and countless examples illustrate that almost all the devices that are in use today are affected by them. Starting in the late 1990s, when Kocher showed that smart cards can be broken using timing or power analysis attacks, there has been a plethora of different side-channel attacks been discovered. Most recently, examples such as Foreshadow illustrate that even advanced computing machinery is vulnerable to side-channel attacks. Leakage resilient cryptography is the discipline that formalises these practical attacks in order to use formal methods for demonstrating security against them. In particular, it defines new security models, so-called leakage models, that incorporate side-channel attacks into the classical security models, and design cryptographic schemes that are provable secure within them.
2	**Learning objectives** Upon successful completion of the module, students will be familiar with the most influential papers on side-channel attacks and leakage resilient cryptography in order to: • Present and understand popular side channel attacks (e.g., power analysis attacks, timing attacks, foreshadow etc.) • Present and understand common countermeasures against side-channel attacks (e.g., constant time cryptography, randomized execution, masking schemes, algorithmic countermeasures, etc.) • Present security models in leakage resilient cryptography and the formal security analysis of side channel countermeasures (e.g., memory leakage models and computation leakage models)
3	**Recommended prerequisites for participation** Recommended: The seminar is aimed at master students. Basic lecture IT security or basic knowledge in cryptography are recommended, but not mandatory.
4	**Form of examination** Course related exam: • [20-00-1088-se] (Study achievement, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible: Colloquium (optional: including presentation), Term Paper.
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1088-se] (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**

Courses

Course nr.	Course name	
20-00-1088-se	Side-channel resilient cryptography	
Instructor	**Type**	**SWS**
Prof. Ph.D. Sebastian Faust	Seminar	2

2.7 Optional Subjects AIS-VC: Visual Computing

Module name					
Computer Graphics I					
Module nr. 20-00-0040	**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. Bernt Schiele		

1	**Teaching content** Introduction to basic principles of computer graphics, in particular input and output devices, rendering using OpenGL, ray tracing, illumination modelling, ongoing development in computer grapics.
2	**Learning objectives** After successful completion of the modul, students are able to understand all components of the graphic pipeline and change variable parts (Vertex-Shader, Fragment-Shader, etc.). They are able to arrange, change and effectively store objects in the 3D-space, as well as appropriately choose the camera and the perspective, and utilize various shading-techniques and lighting-models to adapt all steps on the way to the displayed 2D-Image.
3	**Recommended prerequisites for participation** Recommended: - Programming - Basic algorithm and data structure - Linear algebra - Analysis - Topics of lecture Visual Computing
4	**Form of examination** Course related exam: • [20-00-0040-iv] (Technical examination, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).
5	**Prerequisite for the award of credit points** Pass exam (100%).
6	**Grading** Course related exam: • [20-00-0040-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B. Sc. Informatik M. Sc. Informatik M. Sc. Computer Science M. Sc. Autonome Systeme und Robotik M.Sc. IT Sicherheit May be used in other degree programs.
8	**Grade bonus compliant to §25 (2)** In this course a crediting of lecture-accompanying achievements takes place, which can lead to a grade improvement of up to 1.0 according to 25(2) of the 6th amendment of the General Examination Regulations of the TU Darmstadt and the crediting rules decided by the Department of Computer Science on July 14, 2022.

9	**References** - Real-Time Rendering: Tomas Akenine-Möller, Eric Haines, Naty Hoffman A.K. Peters Ltd., 3rd edition, ISBN 987-1-56881-424-7 - Fundamentals of Computer Graphics: Peter Shirley, Steve Marschner, third edition, ISBN 979-1-56881-469-8 - Additional literature will be given in the lecture.

Courses

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

Module name Visual Computing					
Module nr. 20-00-0014	**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. phil. nat. Marc Fischlin		

1	**Teaching content** - Basics of perception - Basic Fourier transformation - Images, filtering, compression & processing - Basic object recognition - Geometric transformations - Basic 3D reconstruction - Surface and scene representations - Rendering algorithms - Color: Perception, spaces & models - Basic visualization
2	**Learning objectives** After successful participation in the course students are able to describe the foundational concepts as well as the basic models and methods of visual computing. They explain important approaches for image synthesis (computer graphics & visualization) and analysis (computer vision) and can solve basic image synthesis and analysis tasks.
3	**Recommended prerequisites for participation** Recommended: Participation of lecture “Mathematik I/II/III”.
4	**Form of examination** Course related exam: • [20-00-0014-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0014-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 M.Sc. Sportwissenschaft und Informatik B.Sc. Computational Engineering B.Sc. Informationssystemtechnik 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: - R. Szeliski, “Computer Vision: Algorithms and Applications”, Springer 2011 - B. Blundell, “An Introduction to Computer Graphics and Creative 3D Environments”, Springer 2008		
Courses			
	Course nr. 20-00-0014-iv	**Course name** Visual Computing	
	Instructor	**Type** Integrated course	**SWS** 3

Module name Image Processing					
Module nr. 20-00-0155	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1	**Teaching content** Fundamentals of image processing: - Image properties - Image transformations - Simple and complex filtering - Image compression, - Segmentation - Classification
2	**Learning objectives** After successfully completing the course, students have an overview over the mechanisms used in and the abilities of modern image processing techniques. They are able to solve basic to medium level problems in image processing.
3	**Recommended prerequisites for participation**
4	**Form of examination** Course related exam: • [20-00-0155-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0155-iv] (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** - Gonzalez, R.C., Woods, R.E., ""Digital Image Processing"", Addison- Wesley Publishing Company, 1992 - Haberaecker, P., ""Praxis der Digitalen Bildverarbeitung und Mustererkennung"", Carl Hanser Verlag, 1995 - Jaehne, B., ""Digitale Bildverarbeitung"", Springer Verlag, 1997
Courses	

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

Module name Computer Vision I					
Module nr. 20-00-0157	**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. Bernt Schiele		

1	**Teaching content** - Basics of image formation - Linear and (simple) nonlinear image filtering - Foundations of multi-view geometry - Camera calibration and pose estimation - Foundations of 3D reconstruction - Foundations of motion estimation from video - Template and subspace methods for object recognition - Object classification with bag of words - Object detection - Basics of image segmentation
2	**Learning objectives** After successfully attending the course, students are familiar with the basics of computer vision. They understand fundamental techniques for the analysis of images and videos, can name their assumptions and mathematical formulations, as well as describe the resulting algorithms. They are able to implement these techniques in order to solve basic image analysis tasks on realistic imagery.
3	**Recommended prerequisites for participation** Particiation of lecture Visual Computing is recommended.
4	**Form of examination** Course related exam: • [20-00-0157-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0157-iv] (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 recommendations will be updated regularly, an example might be: - R. Szeliski, ""Computer Vision: Algorithms and Applications"", Springer 2011 - D. Forsyth, J. Ponce, ""Computer Vision – A Modern Approach"", Prentice Hall, 2002

Courses

Course nr.	Course name		
20-00-0157-iv	Computer Vision		
Instructor		**Type**	**SWS**
		Integrated course	4

Module name Computer Vision II					
Module nr. 20-00-0401	**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. Bernt Schiele		

1	**Teaching content** - Computer vision as (probabilistic) inference - Robust estimation and modeling - Foundations of Bayesian networks and Markov random fields - Basic inference and learning methods in computer vision - Image restoration - Stereo - Optical flow - Bayesian tracking of (articulated) objects - Semantic segmentation - Current research topics
2	**Learning objectives** After successfully attending the course, students have developed a more in-depth understanding of computer vision. They formulate image and video analysis tasks as inference problems, taking challenges of real applications into account, e.g. regarding robustness. They solve the inference problem using discrete or continuous inference algorithms, and apply these to realistic imagery. They quantitatively evaluate the application specific results.
3	**Recommended prerequisites for participation** Participation of lecture Visual Computing and Computer Vision I is recommended.
4	**Form of examination** Course related exam: • [20-00-0401-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0401-iv] (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 Can 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: - S. Prince, “Computer Vision: Models, Learning, and Inference”, Cambridge University Press, 2012 - R. Szeliski, ""Computer Vision: Algorithms and Applications"", Springer 2011

Courses

Course nr.	Course name		
20-00-0401-iv	Computer Vision II		
Instructor		**Type**	**SWS**
		Integrated course	4

Module name Information Visualization and Visual Analytics					
Module nr. 20-00-0294	**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. Bernt Schiele		

1	**Teaching content** This lecture will give a detailed introduction to the scientific topics of information visualization and Visual Analytics, and will cover current research areas as well as practical application scenarios of Visual Analytics. • Overview of information visualization and Visual Analytics (definitions, models, history) • Data representation and data transformation • Mapping of data to visual structures • Introduction to human cognition • Visual representations and interaction for bivariate and multivariate Data, time series, networks and geographic data • Basic data mining techniques • Visual Analytics - Analytics reasoning - Data mining - Statistics Analytical techniques and scaling • Evaluation of Visual Analytics Systems
2	**Learning objectives** After successfully attending the course, students will be able to • use information visualization methods for specific data types • design interactive visualization systems for data from various application domains • couple visualization and automated methods to solve large-scale data analysis problems • apply knowledge about key characteristics of the human visual and cognitive system for information visualization and visual analytics chose evaluation methods are used for specific situations and scenarios
3	**Recommended prerequisites for participation** Interesse an Methoden der Computergrafik und Visualisierung Die Veranstaltung richtet sich an Informatiker, Wirtschaftsinformatiker, Mathematiker in Bachelor, Master und Diplomstudiengänge und weiteren interessierten Kreisen (z.B. Biologen, Psychologen).
4	**Form of examination** Course related exam: • [20-00-0294-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0294-iv] (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)** 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 announced in lecture, an example might be: C. Ware: Information Visualization: Perception for Design Ellis et al: Mastering the Information Age

Courses

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

Module name					
Advanced User Interfaces					
Module nr. 20-00-0570	**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. Michael Gösele		

1	**Teaching content** - Requirements analysis of a given problem - Design and presentation of a user interface concept - Implementation of a prototype
2	**Learning objectives** Students have been provided insights into the principles and methods to realize multimedial, collaborative and adaptive user interfaces for a given problem.
3	**Recommended prerequisites for participation** - Interesse an neuen, innovativen Benutzungsschnittstellen - Wünschenswert sind Grundkenntnisse der Human Computer Interaction - gute Programmierkenntnisse (C#/WPF und/oder Java)
4	**Form of examination** Course related exam: • [20-00-0570-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0570-pr] (Study achievement, 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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References** Depending on topic.

Courses

Course nr.	Course name		
20-00-0570-pr	Advanced User Interfaces		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Eberhard Mühlhäuser		Internship	4

Module name					
Physically based Simulation and Animation					
Module nr. 20-00-0682	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1	**Teaching content** - Basics of physically based simulation and animation - Equations of motion and modeling of rigid bodies, mass-spring systems, deformable bodies and fluids - Approximate numerical methods for the efficient solution of ordinary and partial differential equations - Parallel computing for physically based simulations - Collision detection and resolution
2	**Learning objectives** After completing the module successfully, the students can - Describe requirements for methods of physically based simulations for computer animation - Apply concepts of physically based simulations - Transfer learned concepts to other simulation applications - Evaluate the suitability of algorithms and numerical methods for physically based simulation - Describe open research questions in physics-based simulation and animation
3	**Recommended prerequisites for participation** - Basic knowledge of numerical computing, algorithms and data structures, computer graphics
4	**Form of examination** Course related exam: • [20-00-0682-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam of Modul (100%)
6	**Grading** Course related exam: • [20-00-0682-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** B.Sc. Informatik M.Sc. Informatik Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

Course nr.	Course name		
20-00-0682-iv	Physically based Simulation and Animation		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Michael Gösele		Integrated course	4

Module name Serious Games Project Seminar					
Module nr. 18-de-2070	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 195 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** PD Dr.-Ing. Stefan Göbel		

1	**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.
2	**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.
3	**Recommended prerequisites for participation** Programming skills (the language will depended on the topic and may be chosen at will for certain topics).
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** Pass exam (100%)
6	**Grading** Module exam: • Module exam (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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References**
Courses	

	Course nr.	Course name		
	18-de-2070-pj	Serious Games Project Seminar		
	Instructor		**Type**	**SWS**
	PD Dr.-Ing. Stefan Göbel		Project seminar	5

Module name Serious Games Seminar					
Module nr. 20-00-0328	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1	**Teaching content** In this seminar the students will analyze and discuss the current state of the art for 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 completing this course the students are able to become acquainted with an unfamiliar subject in the field of "Serious Games". They are familiar with library research techniques for scientific papers and industry sources. The techniques and results mentioned in these references can be summarized, assessed and compared to each other. 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**
4	**Form of examination** Course related exam: • [20-00-0328-se] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0328-se] (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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References**

Courses

	Course nr.	Course name		
	20-00-0328-se	Serious Games Seminar		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Michael Gösele		Seminar	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**

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
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. 18-de-2050-vl	**Course name** Serious Games			
Instructor PD Dr.-Ing. Stefan Göbel			**Type** Lecture	**SWS** 3
Course nr. 18-de-2050-ue	**Course name** Serious Games			
Instructor PD Dr.-Ing. Stefan Göbel			**Type** Practice	**SWS** 1

Module name Image Processing					
Module nr. 20-00-0155	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1	**Teaching content** Fundamentals of image processing: - Image properties - Image transformations - Simple and complex filtering - Image compression, - Segmentation - Classification
2	**Learning objectives** After successfully completing the course, students have an overview over the mechanisms used in and the abilities of modern image processing techniques. They are able to solve basic to medium level problems in image processing.
3	**Recommended prerequisites for participation**
4	**Form of examination** Course related exam: • [20-00-0155-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0155-iv] (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** - Gonzalez, R.C., Woods, R.E., ""Digital Image Processing"", Addison- Wesley Publishing Company, 1992 - Haberaecker, P., ""Praxis der Digitalen Bildverarbeitung und Mustererkennung"", Carl Hanser Verlag, 1995 - Jaehne, B., ""Digitale Bildverarbeitung"", Springer Verlag, 1997
Courses	

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

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** 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**
Courses	

	Course nr.	Course name		
	18-de-2060-pr	Serious Games Lab		
	Instructor		**Type**	**SWS**
	PD Dr.-Ing. Stefan Göbel		Internship	4

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** MSc ETiT, MSc iST, MSc CE, MSc 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, Prof. Dr.-Ing. Jürgen Adamy		Lecture	2

Module name					
Capturing Reality					
Module nr. 20-00-0489	**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. Bernt Schiele		

1	**Teaching content** This course covers a broad range of techniques to capture and model our world with a focus on application in computer graphics and computer vision. This includes: - basic tools and calibration techniques required in capturing applications - capturing and modeling techniques for various object properties (such as geometry and reflectance) - basic set of relevant mathematical modeling and optimization techniques - implementation and practical application of several techniques
2	**Learning objectives** After successful completion of the course, students are able to analyze digitization and modeling problems for objects and scenes in computer graphics and computer vision as well as the underlying techniques. They are able to develop new setups, perform experiments and evaluate the results.
3	**Recommended prerequisites for participation** Recommended: Participation in lecture Graphische Datenverarbeitung I or Computer Vision I Basic knowledge in C/C++
4	**Form of examination** Course related exam: • [20-00-0489-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0489-iv] (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 Can 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**

	Noriko Kurachi: The Magic of Computer Graphics. A K Peters/CRC Press Richard Szeliski: Algorithms and Applications, Springer Marcus Magnor, Oliver Grau, Olga Sorkine-Hornung, Christian Theobalt: Digital Representations of the Real World: How to Capture, Model, and Render Visual Reality Wolfgang Förstner, Bernhard P. Wrobel: Photogrammetric Computer Vision - Geometry, Orientation and Reconstruction

Courses

Course nr.	Course name		
20-00-0489-iv	Capturing Reality		
Instructor		**Type**	**SWS**
Prof. Dr. Bernt Schiele		Integrated course	4

Module name Geometric Methods of CAE/CAD					
Module nr. 20-00-0140	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1	**Teaching content** - parametric curve models - parametric surface models - topology and volumetric CAD models - CAD operations on surfaces - tesselation - approximation of curves and surfaces - finite element method and computational fluid dynamics - various applications from the area of CAD
2	**Learning objectives** After successfully attending the course, students understand the foundations of computer-aided methods for geometric modelling and simulation. They understand multiple parametric representations for curves and surfaces and are able to analyze and compare them. They know classical data structures and algorithms from computer aided design (CAD). They can use the presented techniques to model and visualize 3D geometry.
3	**Recommended prerequisites for participation** Basic knowledge in Computer Science.
4	**Form of examination** Course related exam: • [20-00-0140-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0140-iv] (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)** 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**

	Vorlesungsfolien Lee: Principles of CAD / CAM / CAE Systems, Addison-Wesley. Piegl, Tiller: The NURBS Book, Springer Verlag. Farin: Kurven und Flächen im Computer Aided Geometric Design, vieweg Shah, Mäntylä: Parametric and Feature-based CAD/CAM, Wiley & Sons

Courses

Course nr.	**Course name**		
20-00-0140-iv	Geometrical Methods of CAE/CAD		
Instructor		**Type**	**SWS**
		Integrated course	3

Module name Programming Massively Parallel Processors					
Module nr. 20-00-0419	**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. Bernt Schiele		

1	**Teaching content** - foundations of massively parallel processors with a focus on modern accelerator hardware - parallel algorithms - efficient programming of massively parallel systems - practical programming projects co-advised by domain scientists
2	**Learning objectives** After successful completion of the course, students are able to analyze problems in the context of massively parallel systems. They can develop novel applications and systematically improve their performance. They understand basic parallel algorithms and are able to independently understand and analyze current literature.
3	**Recommended prerequisites for participation** Programming skills in C/C++ Recommended: Systemnahe und Parallele Programmierung
4	**Form of examination** Course related exam: • [20-00-0419-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0419-iv] (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 Can 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 02.10.2012 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
9	**References** Will be announced in lecture.
Courses	

	Course nr.	Course name		
	20-00-0419-iv	Programming Massively Parallel Processors		
	Instructor		**Type**	**SWS**
			Integrated course	4

<table>
<tr><td colspan="6">Module name
Advanced Visual Computing Lab</td></tr>
<tr><td>Module nr.
20-00-0537</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
German/English</td><td colspan="3">Module owner
Prof. Dr. Bernt Schiele</td></tr>
</table>

1	**Teaching content** Students work in this lab on selected advanced topics in the area of visual computing. Project results will be presented in a talk at the end of the course. The specific topics addressed in the lab change every semester and should be discussed directly with one of the instructors.
2	**Learning objectives** After successful completion of this course, the students will be able to independently analyze and solve an advanced problem in the area of visual computing and to evaluate the results.
3	**Recommended prerequisites for participation** Programming skills, e.g. Java, C++ Basic knowledge in Visula Computing Participation in at least one basic lectures and one lab in the are of Visual Computing.
4	**Form of examination** Course related exam: • [20-00-0537-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0537-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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be announced in lecture.

Courses

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

Module name Augmented Vision					
Module nr. 20-00-0160	**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. Bernt Schiele		

1	**Teaching content** This course starts to detail the principal concepts of Augmented and Virtual Reality in relation to Computer Graphics and Computer Vision. Starting from here basic principles, methods, algorithms as well as relevant standards are discussed. This includes - VR/AR specific requirements and interfaces - Interaction technologies (e.g. interaction with range camera technologies) - Rendering technologies (in particular real-time rendering) - Web-based VR and AR - Computer-Vision-based Tracking - Augmented Reality with range camera technologies - Augmented Reality on smartphone platforms The technologies will be illustrated and discussed with the results of actual research projects including in application fields „AR-maintenance support“ and „AR/VR based Cultural Heritage presentation“.
2	**Learning objectives** After successfully attending the course, students are familiar with the challenges and the requirements of Virtual and Augmented reality applications. They know the standards used for the specification of VR/AR-applications. In particular, the students understand the potential of Computer Vision based tracking and they can decide which methods can be applied in with environment.
3	**Recommended prerequisites for participation** Grundlagen der Graphischen Datenverarbeitung (GDV)
4	**Form of examination** Course related exam: • [20-00-0160-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0160-iv] (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** Dörner, R., Broll, W., Grimm, P., Jung, B. Virtual und Augmented Reality (VR / AR)

Courses

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

Module name 3D Animation & Visualization					
Module nr. 20-00-0216	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. Bernt Schiele		

1	**Teaching content** This seminar focuses on current research topics and the latest results in the areas of physically-based simulation, animation, real-time rendering and visualization. - participants independently familiarize themselves with the assigned seminar topic by working with the provided scientific papers (usually texts written in English) - classification and interpretation of the gathered research results - preparation of a textual summary and a slide-based presentation on the subject - presentation in front of an audience with mixed prior knowledge on the topic and discussion
2	**Learning objectives** Successful participation in the course enables students to get expertise by working with scientific papers. They can extract the essential aspects of the examined works and are able to concisely present them as textual form and presentation, targeting an audience with mixed prior experience on the subject. The students are able to actively participate in a scientific discussion on the presented topics.
3	**Recommended prerequisites for participation** GDV I, (GDV II)
4	**Form of examination** Course related exam: • [20-00-0216-se] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0216-se] (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** Selected articles from ACM SIGGRAPH, EUROGRPAHICS, IEEE and similar Conferences. All articles are written in English.
Courses	

	Course nr.	Course name		
	20-00-0216-se	3D Animation & Visualization		
	Instructor		**Type**	**SWS**
			Seminar	2

Module name Ambient Intelligence					
Module nr. 20-00-0390	**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. Bernt Schiele		

1	**Teaching content** The course will provide an overview of a new vision for Human-Computer-Interaction (HCI) in which people are surrounded by intelligent and intuitive interfaces embedded in the everyday objects around them. In specific the course addresses the emergence of Ambient Mobility and the ubiquitous, pervasive information access, retrieval and display on mobile devices. It will focus on understanding enabling technologies and studying applications and experiments, and, to lesser extent, it will adress the sociocultural impact. Additional topics of the lecture include system architectures for distributed systems, context awareness and management, user models and their implications, sensing and interaction in smart environments. The lecture discusses recent topics and research projects in the domain of Ambient Intelligence.
2	**Learning objectives** After successfully attending the lecture, the students will be able to describe technology trends and research results in the domain of Ambient Intelligence. The most important concepts to create smart environments - intelligent networks and objects, technologies for mobile, augmented reality, ubiquitous and pervasive information spaces, nomadic communications, real-time communication and related middle ware, embedded systems, sensor networks and wearable computing - can be discussed and classified. After completing the practical part, students will be able to plan and realize the different project phases required to develop an Ambient-Intelligence solution.
3	**Recommended prerequisites for participation** Master-Students Participation in lecture "Visual Computing“ and „Multimodale Interaktion mit intelligenten Umgebungen“
4	**Form of examination** Course related exam: • [20-00-0390-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0390-iv] (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 Can 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** Will be given according to actual topics.

Courses

Course nr.	**Course name**		
20-00-0390-iv	Ambient Intelligence		
Instructor		**Type**	**SWS**
		Integrated course	4

Module name					
Computer Graphics II					
Module nr. 20-00-0041	**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. Bernt Schiele		

1 Teaching content

Foundations of the various object- and surface-representations in computer graphics. Curves and surfaces (polynomials, splines, RBF) Interpolation and approximation, display techniques, algorithms: de Casteljau, de Boor, Oslo, etc. Volumes and implicit surfaces. visualization techniques, iso-surfaces, MLS, surface rendering, marching cubes. Meshes, mesh compression, mesh simplication, multiscale expansion, subdivision. Pointclouds: rendering techniques, surface reconstruction, voronoi-diagram and delaunay-triangulation.

2 Learning objectives

After successful completion of the module, students are able to handle various object- and surface-representations, i.e., to use, adapt, display (render), and effectively store these objects. This includes mathematical polynomial representations, iso-surfaces, volume representations, implicite surfaces, meshes, subdivision control meshes and pointclouds.

3 Recommended prerequisites for participation

Recommended:

- Algorithmen und Datenstrukturen
- Grundlagen aus der Höheren Mathematik
- Graphische Datenverarbeitung I
- C / C++

4 Form of examination

Course related exam:

- [20-00-0041-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:

- [20-00-0041-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

7 Usability of the module

B. Sc. Informatik
M. Sc. Informatik
M. Sc. Computer Science
M.Sc. IT Sicherheit

May be used in other degree programs.

8 Grade bonus compliant to §25 (2)

In this course a crediting of lecture-accompanying achievements takes place, which can lead to a grade improvement of up to 1.0 according to 25(2) of the 6th amendment of the General Examination Regulations of the TU Darmstadt and the crediting rules decided by the Department of Computer Science on July 14, 2022.

<table>
<tr><td>9</td><td colspan="4">References
- Real-Time Rendering: Tomas Akenine-Möller, Eric Haines, Naty Hoffman A.K. Peters Ltd., 3rd edition, ISBN 987-1-56881-424-7
- Additional literature will be given in the lecture.</td></tr>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
20-00-0041-iv</td><td colspan="3">Course name
Computer Graphics II</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Integrated course</td><td>SWS
4</td></tr>
</table>

Module name Probabilistic Graphical Models					
Module nr. 20-00-0449	**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. Ph. D. Stefan Roth		

1	**Teaching content** - Refresher of probability & Bayesian decision theory - Directed and undirected models and their properties - Inference in tree graphs - Approximate inference in general graphs: Message passing and mean field - Learning of directed and undirected models - Sampling methods for learning and inference - Modeling in example applications, including topic models - Deep networks - Semi-supervised learning
2	**Learning objectives** After successfully attending the course, students have developed an in-depth understanding of probabilistic graphical models. They describe and analyze properties of graphical models, and formulate suitable models for concrete estimation and learning tasks. They understand inference algorithms, judge their suitability and apply them to graphical models in relevant applications. Moreover, they determine which learning algorithms are suitable to estimate the model parameters from example data, and apply these.
3	**Recommended prerequisites for participation** Recommended: Participation in “Statistisches Maschinelles Lernen”.
4	**Form of examination** Course related exam: • [20-00-0449-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0449-iv] (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 Can 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: - D. Barber: "Bayesian Reasoning and Machine Learning", Cambridge University Press 2012 - D. Koller, N. Friedman: "Probabilistic Graphical Models: Principles and Techniques", MIT Press 2009

Courses

Course nr.	**Course name**		
20-00-0449-iv	Probabilistic Graphical Models		
Instructor		**Type**	**SWS**
		Integrated course	4

<table>
<tr><td colspan="6">Module name
Visual Computing Lab</td></tr>
<tr><td>Module nr.
20-00-0418</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
German/English</td><td colspan="3">Module owner
Prof. Dr. Bernt Schiele</td></tr>
</table>

1 Teaching content

Students work in this lab on selected topics in the area of visual computing. Project results will be presented in a talk at the end of the course. The specific topics addressed in the lab change every semester and should be discussed directly with one of the instructors.

2 Learning objectives

After successful completion of this course, the students will be able to independently analyze and solve a problem in the area of visual computing and to evaluate the results.

3 Recommended prerequisites for participation

Practical programming skills, e.g. Java, C++
Basic knowledge or interest within Visual Computing
Participation in one basic lecture within Visiual Computing

4 Form of examination

Course related exam:
- [20-00-0418-pr] (Study achievement, Oral/written examination, Default RS)

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:
- [20-00-0418-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

Can be used in other degree programs.

8 Grade bonus compliant to §25 (2)

9 References

Will be announced in course.

Courses

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

Module name					
Scale Space and PDE methods in image analysis and processing					
Module nr. 20-00-0469	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Bernt Schiele		

1 Teaching content

Image analysis & processing deals with the investigation of images and the application of specific tasks on them, like enhancement, denoising, deblurring, and segmentation. In this course, mathematical methods that are commonly used are presented and discussed. The focus will be on the axiomatic choice for the models, their mathematical properties, and their practical use.

Some key words:
- Filtering (Edge detection, enhancement, Wiener, Fourier, ...)
- Images & Observations: Scale space, regularisation, distributions
- Objects: Differential structure, invariants, feature detection
- Deep structure: Catastrophes & multi-scale hierarchy
- Variational Methods & Partial Differential Methods: Perona Malik, anisotropic diffusion, total variation, Mumford-Shah, Chan-Vese, geometric PDEs, level sets
- Curve Evolution: Normal motion, mean curvature motion, Euclidean shortening flow.

2 Learning objectives

After successful participation in the course students are able to describe the foundational mathematical concepts as well as the basic models and methods of image analysis and processing. They explain important approaches for scale space and PDE methods and can evaluate, transfer, and explain representative technical papers.

3 Recommended prerequisites for participation

Da Bildanalyse und -verarbeitung eine Mischung aus verschiedenen Disziplinen, wie Physik, Mathematik, Vision, Informatik und Engineering, ist, ist dieser Kurs gezielt auf ein breites Publikum zugeschnitten. Daher werden nur Grundkenntnisse in Analysis angenommen. Weitere notwendige mathematische Werkzeuge werden in den Sitzungen skizziert.

4 Form of examination

Course related exam:
- [20-00-0469-se] (Study achievement, Oral/written examination, Default RS)

5 Prerequisite for the award of credit points

Pass exam (100%)

6 Grading

Course related exam:
- [20-00-0469-se] (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

Can be used in other degree programs.

<table>
<tr><td>8</td><td colspan="4">Grade bonus compliant to §25 (2)</td></tr>
<tr><td>9</td><td colspan="4">References
Main:
- B. M. ter Haar Romeny, Front-End Vision and Multi-scale Image Analysis, Dordrecht, Kluwer Academic Publishers, 2003.
Recommended:
- T. Lindeberg: Scale-Space Theory in Computer Vision, Dordrecht, Kluwer Academic Publishers, 1994.
- J. Weickert: Anisotropic Diffusion in Image Processing, Teubner-Verlag, Stuttgart, Germany, 1998.
G. Aubert & P. Kornprobst: Mathematical problems in image processing: Partial Differential Equations and the Calculus of Variations (second edition), Springer, Applied Mathematical Sciences, Vol 147, 2006.</td></tr>
<tr><td colspan="5">Courses</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
20-00-0469-se</td><td colspan="3">Course name
Scale space and PDE methods in image analysis and processing</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Seminar</td><td>SWS
2</td></tr>
</table>

Module name					
Visual Analytics: Interactive Visualization of Very Large Data					
Module nr. 20-00-0268	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1	**Teaching content** This seminar is targeted at computer science students with an interest in information visualization, in particular the visualization of extremely large data. Students will analyze and present a topic from visual analytics. They will also write a paper about this topic.
2	**Learning objectives** After successfully completing the course, students are able to analyze and understand a scientific problem based on the literature. Students are able to present and discuss the topic.
3	**Recommended prerequisites for participation** Interesse sich mit einer graphisch-analytischen Fragestellung bzw. Anwendung aus der aktuellen Fachliteratur zu befassen. Vorkenntnisse in Graphischer Datenverarbeitung, Informationssysteme oder Informationsvisualisierung
4	**Form of examination** Course related exam: • [20-00-0268-se] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0268-se] (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**

Courses

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

Module name Visualization and Animation of Algorithms and Data Structures					
Module nr. 20-00-0344	**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. Bernt Schiele		

1	**Teaching content** The students will be enabled to create animations of algorithms and data structures to enhance the learning process. The contents will be usable for studying the topics covered and can be used in the ICS / GdI 2 lecture. The competencies gained especially include: * Becoming familiar with a complex software system for animating algorithms and data structures * Familiarization with a scripting language, a Java-based API and a framework for generators for creating animations. * Design and implementation of at least two generators for algorithm or data structure animations * Learning criteria for determining if animations support learning processes * Creation and provision of contents ready for use in teaching and self-study * Competent use of the CS learning platform for submitting feedback and finished tasks
2	**Learning objectives** After taking part in this lab, students will be able to... - use the provided API for animating algorithms. - analyze a given algorithm with regard to its central elements. - construct one visualization each for the central elements of two chosen algorithms. - generalize the generated visualizations by an appropriate support of adjustable parameters. - critically reflect whether the created visualization will support the learning process of the viewer.
3	**Recommended prerequisites for participation** Participants need good Java programming skills and should be familiar with the algorithms and data structures taught in ICS 2.
4	**Form of examination** Course related exam: • [20-00-0344-pr] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0344-pr] (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		
	20-00-0344-pr	Visualization and Animation of Algorithms and Data Structures		
	Instructor		**Type**	**SWS**
			Internship	4

Module name Applied Topics in Computer Graphics					
Module nr. 20-00-0724	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1	**Teaching content** Selected papers from the following fields of computer graphics: - Visualization / Rendering - Simulation - Geometry processing and modeling - Semantics and 3D
2	**Learning objectives** After successfully completing the course, students know selected current topics in computer graphics. They are able to independently analyze the content of a scientific publications, to understand and to present the problem as well as the proposed solution. Furthermore, they can analyze and present directions for further improvements in the area.
3	**Recommended prerequisites for participation** Prior knowledge of GDV or geom. methods of CAD/CAE is advantageous
4	**Form of examination** Course related exam: • [20-00-0724-se] (Study achievement, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0724-se] (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 Can be used in other degree programs.
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be given in seminar.
Courses	

	Course nr.	Course name		
	20-00-0724-se	Applied Topics in Computer Graphics		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Michael Gösele		Seminar	2

Module name User-Centered Design in Visual Computing					
Module nr. 20-00-0793	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1	**Teaching content** Developing user-centered software leads to a more efficient usage and increases the acceptance by the human user. The higher acceptance leads to a better dissemination and exploitation of the developed solutions. The lecture “User Centered Design in Visual Computing” aims at enabling students from the department of computer science to acquire knowledge about models, methods, and techniques for user-centered development of visualizations and interactive visual representations. This course will introduce methods that lead to designing more efficient solutions with higher acceptance. Furthermore, the lecture will explain evaluation methods that allow measuring acceptance and efficiency. User Centered Design introduces the mentioned topics with a special focus on visual computing and graphical user interfaces. Content: • Usability • User experience • Task analysis • User interfaces • Interaction design • Prototyping • Graphics design and information visualization • Evaluation during and after software development • Applications and examples
2	**Learning objectives** After a successful participation, students will be able to: • Identify and argue about adequate methods for developing user-centered software • Apply techniques for user-centered visual interfaces • Identify and choose adequate evaluation methods for the chosen techniques in the different stages of software development • Recommend improvements for information acquisition and navigation based on studies and evaluations
3	**Recommended prerequisites for participation** • Basics of visual computing, as e.g. taught in the introductory course HCS and in the course GDV I
4	**Form of examination** Course related exam: • [20-00-0793-iv] (Technical examination, Oral/written examination, Default RS)
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-0793-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 M.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
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**

Courses

Course nr.	**Course name**		
20-00-0793-iv	User-Centered Design in Visual Computing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Michael Gösele		Integrated course	2

Module name Hands-On HCI					
Module nr. 20-00-1116	**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. Arjan Kuijper		

1	**Teaching content** You might have previously heard of or even tried out virtual/augmented reality, 3D printing, wearable or tangible user interfaces. The area of Human-Computer Interaction covers all these exciting topics and offers an opportunity to build new prototypes and try them out with people in the user studies. If you would like to better connect theory and practice in the area of Human-Computer Interaction (HCI), then the course of Hands-On Human-Computer Interaction (Hands-On HCI) is for you. The goal of the class is to walk you through the whole research cycle in HCI. It can play a great preparation role for your future bachelor/master thesis in HCI or lay a first brick in your academic path after finishing your studies.
2	**Learning objectives** After completing the module, students can - differentiate between and apply three approaches to HCI research. - distinguish three types of empirical research. - effectively read a scientific publication. - differentiate between types of HCI contributions. - Formulate and define research questions, hypotheses and experimental variables. - create a suitable study design based on the previously developed research questions. - conduct a study using quantitative and qualitative methods to collect data. - Analyze, evaluate and interpret quantitative data on the basis of statistical methods. - Analyze and interpret qualitative data on the basis of grounded theory. - Understand the peer review process and write reviews for a scientific publication. - Understand and apply evaluation techniques with and without users. - Write the knowledge gained as a scientific publication and present it to a specialist audience.
3	**Recommended prerequisites for participation** Recommended: Human-Computer Interaction (TK2)
4	**Form of examination** Course related exam: • [20-00-1116-iv] (Technical examination, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).
5	**Prerequisite for the award of credit points** Pass exam (100%)
6	**Grading** Course related exam: • [20-00-1116-iv] (Technical examination, 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**

Courses			
	Course nr. 20-00-1116-iv	**Course name** Hands-On HCI	
	Instructor Prof. Dr. Arjan Kuijper	**Type** Integrated course	**SWS** 4

2.8 Optional Subjects AIS-EC: Economics

<table>
<tr><td colspan="7">Module name
Introduction to Business Administration</td></tr>
<tr><td colspan="2">Module nr.
01-10-1028/f</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
German</td><td colspan="3">Module owner
Prof. Dr. rer. pol. Dirk Schiereck</td></tr>
<tr><td>1</td><td colspan="6">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.</td></tr>
<tr><td>2</td><td colspan="6">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.</td></tr>
<tr><td>3</td><td colspan="6">Recommended prerequisites for participation
None</td></tr>
<tr><td>4</td><td colspan="6">Form of examination
Module exam:
• Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)</td></tr>
<tr><td>5</td><td colspan="6">Prerequisite for the award of credit points
Passing the examination</td></tr>
<tr><td>6</td><td colspan="6">Grading
Module exam:
• Module exam (Technical examination, Examination, Weighting: 100 %)</td></tr>
<tr><td>7</td><td colspan="6">Usability of the module</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
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.</td></tr>
</table>

Courses				
	Course nr. 01-10-0000-vl	**Course name** Introduction to Business Administration		
	Instructor		**Type** Lecture	**SWS** 2

Module name Financial Accounting and Reporting					
Module nr. 01-14-1B01	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr. rer. pol. Reiner Quick		

1	**Teaching content** Financial Accounting: Fundamentals of accounting and bookkeeping, inventory, balance sheet, recording of assets and debt, recording of expenses and revenues, selected transactions (sales and purchases, non-current assets, current assets, accruals, wage and salary, distribution of earnings), annual closing entry. Financial Reporting: Fundamentals of accounting based on the rules of the German Commercial Code (HGB), accounting concepts, purpose of accounting, bookkeeping, inventory, recognition and measurement of assets and liabilities, income statement, notes, management report.
2	**Learning objectives** After the course students are able to • understand the core principles of bookkeeping, inventory and preparation of the balance sheet • book stocks and profit • solve specific bookkeeping problems in the fields of sales and purchases, non-current and current assets, accruals, wage and salary, distribution of earnings • understand of the steps prior to the preparation of annual financial statements according to the German Commercial Code (HGB) • analyze of the recognition and measurement of assets and liabilities • understand of Income statements, notes and management reports • solve accounting cases in the context of the German Commercial Code (HGB)
3	**Recommended 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) • Module exam (Study achievement, Oral/written examination, Duration: 45 Min., Default RS) Supplement to Assessment Methods: The academic achievement needs to be passed to take part in the module exam.
5	**Prerequisite for the award of credit points** Passing the Examination
6	**Grading** Module exam: • Module exam (Technical examination, Written examination, Weighting: 2) • Module exam (Study achievement, Oral/written examination, Weighting: 1)
7	**Usability of the module** B.Sc. Wirtschaftsingenieurwesen, B.Sc. Wirtschaftsinformatik
8	**Grade bonus compliant to §25 (2)**
9	**References** Quick, R./ Wurl, H.-J: Doppelte Buchführung, 2. Aufl., Wiesbaden: Gabler. Quick, R./Wolz, M.: Bilanzierung in Fällen. 4. Auflage. Schäffer Poeschel, Stuttgart Further literature will be announced in the lecture.

Courses				
	Course nr. 01-14-0001-vu	**Course name** Bookkeeping		
	Instructor Prof. Dr. rer. pol. Reiner Quick		**Type** Lecture and practice	**SWS** 2
	Course nr. 01-14-0003-vu	**Course name** Financial Accounting		
	Instructor Prof. Dr. rer. pol. Reiner Quick		**Type** Lecture and practice	**SWS** 2
	Course nr. 01-14-0001-tt	**Course name** Bookkeeping		
	Instructor Prof. Dr. rer. pol. Reiner Quick		**Type** Tutorial	**SWS** 1
	Course nr. 01-14-0003-tt	**Course name** Financial Accounting		
	Instructor Prof. Dr. rer. pol. Reiner Quick		**Type** Tutorial	**SWS** 1

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
Technology and Innovation Management

Module nr.	Credit points	Workload	Self-study	Module duration	Module cycle
01-22-0M05/6	6 CP	180 h	120 h	1 Term	Every Semester

Language	Module owner
English	Prof. Dr. Alexander Kock

1 Teaching content

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

2 Learning objectives

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

3 Recommended prerequisites for participation

Prerequisites: none
Previous Knowledge: see initial skills

4 Form of examination

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

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

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

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

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	

<table>
<tr><td rowspan="2"></td><td>Course nr.
01-22-2B01-vl</td><td colspan="3">Course name
Introduction to Innovation Management</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. Alexander Kock</td><td>Type
Lecture</td><td>SWS
2</td></tr>
</table>

Module name
Basic Principles of Patent and Copyright Law

Module nr.	Credit points	Workload	Self-study	Module duration	Module cycle
01-41-1127	3 CP	90 h	60 h	1 Term	Every Semester

Language	Module owner
German	Prof. Dr. jur. Jochen Marly

1 Teaching content

Introduction, Overview on the Intellectual Property Rights, Literature, General Right of Privacy, "The right of the own picture", Protection of the Name, The work of the author, The author, The Content of the Copyright I, the Content of the Copyright II, Limitations of the Copyright Law, Marketing companies, The Copyright Law in legal matters, Publishing contracts, International Copyright Law, Theory of the Industrial Property Rights, Object of protection and provisions of protection of a patent, The inventor, The creation of a patent, content and limitations of a patent, Infringements of right

2 Learning objectives

After the course the students are able to

- state their view on existing legal structures of solutions. Because of many problems of detail only an exemplary learing has a good prospect for a successful achievement.

3 Recommended prerequisites for participation

4 Form of examination

Module exam:

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

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

to be announced in class.

Courses

Course nr.	Course name		
01-41-0002-vl	Introduction to Patent and Copyright Law		
Instructor		**Type**	**SWS**
Prof. Dr. jur. Jochen Marly		Lecture	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/English			**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

2.9 Optional Subjects AIS-EI: Entrepreneurship and Management

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.

Courses				
	Course nr. 01-10-0000-vl	**Course name** Introduction to Business Administration		
	Instructor		**Type** Lecture	**SWS** 2

Module name					
Leadership and Human Resource Management Systems					
Module nr. 01-17-6201/6	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language English			**Module owner** Prof. Dr. Dr. Ruth Stock-Homburg		

1 Teaching content

Leadership:
- Central approaches and theories of employee and team leadership
- Methods of leadership research
- Success factors of employee leadership
- Leadership of the future
- Special application areas of leadership (e.g. regional distributed or virtual leadership)

Future of Work:
- Influence of new technologies and digitization on the world of work
- Future development and design approaches in human resources management
- Approaches to measuring the sustainability of companies and individuals
- Special challenges of the future of work (e.g. telework/well-being, electronic accessibility, new technologies)

2 Learning objectives

After the course students are able to,
- explain, compare and contrast the key theoretical concepts of employee and team leadership.
- apply the instruments and tools available for leading employees and teams.
- assess the challenges of leading employees and teams in an international environment.
- explain important theories, techniques, and concepts about the future of work.
- interpret and reflect on important parameters for the Future Fitness of employees, leaders, and companies.
- better assess where they personally stand in terms of their individual Future Fitness and face the future of work with curiosity.
- reflect on challenges in the future of work.
- apply learned concepts and instruments in case studies.
- connect their knowledge to business cases in presentations of experienced practitioners.

3 Recommended prerequisites for participation

Sufficient English skills to follow the lecture in English and to understand and answer the English-language written exam.

4 Form of examination

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

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

5 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. Wirtschaftsingenieurwesen, M.Sc. Wirtschaftsinformatik, M.Sc. Entrepreneurship and Innovation Management, M.Sc. Logistics and Supply Chain Management
8	**Grade bonus compliant to §25 (2)**
9	**References** Stock-Homburg, R. & Groß, M. (2019), Personalmanagement: Theorien - Konzepte - Instrumente, Wiesbaden, 4th Edition, Kap. IV. Stock-Homburg, R. (2020a), Chapter 1: The Dodo Effect and Our Future Fitness, in: Stock-Homburg, R., Two Steps Ahead, TU Darmstadt. (working paper) Stock-Homburg, R. (2020b), Chapter 2: Future Orientation, in: Stock-Homburg, R., Two Steps Ahead, TU Darmstadt. (working paper) Stock-Homburg, R. & Lukoschek, C. (2019), Measuring and Designing Future Fitness with the Future Work Navigator (Zukunftsfähigkeit messen und gestalten mit dem Future Work Navigator), p. 191-207, in: Groß, M., Müller-Wiegand, M., & Pinnow, D. F. (Hrsg.), Zukunftsfähige Unternehmensführung: Ideen, Konzepte und Praxisbeispiele, Berlin: Springer Gabler. (translated from German) Further literature will be announced in the lecture.

Courses

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

Module name Technology and Innovation Management					
Module nr. 01-22-0M05/6	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language English			**Module owner** Prof. Dr. Alexander Kock		

1 Teaching content

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

2 Learning objectives

After the course the students are able to

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

3 Recommended prerequisites for participation

Prerequisites: none
Previous Knowledge: see initial skills

4 Form of examination

Module exam:

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

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

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

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

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.	Course name		
	01-22-2B01-vl	Introduction to Innovation Management		
	Instructor		**Type**	**SWS**
	Prof. Dr. Alexander Kock		Lecture	2

Module name					
HIGHEST lecture series - From the concept to your own company					
Module nr. 01-27-0Z01	**Credit points** 2 CP	**Workload** 60 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr. rer. pol. Carolin Bock		

1 Teaching content

The HIGHEST lecture series introduces students to the process of founding a startup. The aim of the lecture is to raise students' awareness of startup-related topics and entrepreneurial thinking. Various topics of the multi-layered start-up process are discussed and underpinned by numerous exciting examples from practice. The aim is to convey contents that are helpful for a successful founding process and enable entrepreneurial action.

Exemplary topics are:
- writing a business plan, financing, grants and funding programs, founder skills, founder teams,
- idea generation, innovations, investors, creative techniques, marketing and sales in startups,
- ecosystems and networks, legal, social entrepreneurship and more.

Among other things, the lecture series will address these questions:
- What is innovation, and what are the paths to commercialization?
- How does an innovation become a business idea and ultimately a company?
- How do I know I'm a founder?
- What skills and competencies does a founding team need? Who do I involve and who not?
- How do I build a business?
- How do I lead a team?
- How do I get customers?
- How do I do business with other companies?
- What (legal) measures are there to protect my idea or research result?
- What financing options, funding programs or support services are available?
- What should I look out for when approaching financiers and Venture Capitalists?
- How do I negotiate conditions skillfully?
- What are positive examples, pioneers or unicorns and what can I learn from them?

Numerous speakers will be integrated into the lectures to share their experience and ensure a high level of practical relevance.

2 Learning objectives

Through the course, students are better able to assess their own abilities as founders. Students know the opportunities and challenges of the startup process. Students know the individual steps of a startup process and are supported and motivated to pursue their own startups. Students know the network and environment of the TU Darmstadt and know where they can get which support.

3 Recommended prerequisites for participation

The lecture series is suitable for all students (Bachelor/Master) and does not require any special knowledge.

4 Form of examination

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

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

5 Prerequisite for the award of credit points

Passing the examination

6 Grading

	Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)
7	**Usability of the module** General Catalogue of the Department of Law and Economics
8	**Grade bonus compliant to §25 (2)**
9	**References** Will be announced in the course.

Courses

Course nr.	Course name
01-27-0Z01-vl	HIGHEST lecture series - From the concept to your own company

Instructor	Type	SWS
Prof. Dr. rer. pol. Carolin Bock	Lecture	0

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 German and International Corporate Law					
Module nr. 01-42-1B01/4	**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. jur. Janine Wendt		

1	**Teaching content** The lecture is divided into two parts: The first part is an introduction to commercial law. The aim is to understand the importance of contract drafting in a company and to take into account the main aspects of commercial law regulations. The second part is devoted to company law, in particular the law of commercial partnerships and corporations. It also deals with the basic issues of good corporate governance and the importance of compliance. European company law will also be introduced. Recitation: This course discusses practical cases concerning commercial law and general company law. In preparation for the exam, sample cases will be discussed.
2	**Learning objectives** After the course students are able to • recognise the conditions for the application of commercial law. • distinguish between the different commercial intermediaries. • understand the basic structures of the most important forms of partnerships and corporations as legal entities for companies. • understand the importance of good corporate governance and the importance of compliance for companies. • deal with different legal texts. • understand the significance of European legal developments for German law and in particular for the protection of investors. • understand the context of legal regulations (e.g. sales law + commercial law + company law). • work on simple facts of the German commercial and company law, as well as the financial market law by applying a legal approach and to compile answers to simple legal questions independently. • generally recognise, assess and respond to the possibilities and risks of liability in legal matters.
3	**Recommended prerequisites for participation** Prerequisites: none Previous Knowledge: see initial skills and contract law
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**

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

Courses

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

Module name Introduction to Law					
Module nr. 01-40-1033/f	**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. jur. Janine Wendt		

1	**Teaching content** The lecture provides a broad insight into the most important legal fields of daily life - e.g.: • The law of sales contracts • Tenancy law • Family law • Employment law • Corporate law etc. These will be illustrated by means of practical cases. Important points of how to frame a contract will be discussed.
2	**Learning objectives** The students will acquire knowledge of the basic principles of German civil law.
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**
8	**Grade bonus compliant to §25 (2)**
9	**References** BGB-Gesetzestext(z.B. Beck-Texte im dtv) Materialien zum Download auf der Homepage des Fachgebiets.

Courses

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

Module name					
Digital Product and Service Marketing					
Module nr. 01-17-6200/6	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language English			**Module owner** Prof. Dr. Dr. Ruth Stock-Homburg		

1	**Teaching content** Digital Product and Service Marketing: Selected topics in the context of digital marketing; including micro and macro environment, digital marketing strategies, the digital marketing mix, digital relationship marketing, communication strategies and channels for digital customers, and evaluation of approaches. Digital Innovation Marketing:Selected topics in the context of digital innovation marketing, including basic information about innovation, key innovation strategies; important theoretical concepts of innovation management; customer integration in the innovation process; and new innovation types, such as user innovation.
2	**Learning objectives** After the course students are able to • recognize the role of digitization for marketing and to estimate potentials. • evaluate approaches in the context of digital marketing. • explain different phases and tools for digital marketing. • explain the process and the organizational design elements of a holistic and customer-oriented innovation management. • recognize the potential of user innovations and co-opetition • critically reflect on ethical aspects of marketing. • apply the concepts and instruments dealt with to practice-oriented questions using specific examples. • transfer the learned contents to business practice through guest lectures.
3	**Recommended prerequisites for participation** Marketing Sufficient English skills to follow the lecture in English and to understand and answer the English-language written exam.
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Default RS) Supplement to Assessment Methods Oral/written: Type and duration of exam are announced by the beginning of the course Written: exam (duration 60 - 90 minutes) Oral: team or individual exam (duration 15 - 20 minutes per participant)
5	**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. Wirtschaftsingenieurwesen, M.Sc. Wirtschaftsinformatik, M.Sc. Entrepreneurship and Innovation Management, M.Sc. Logistics and Supply Chain Management
8	**Grade bonus compliant to §25 (2)**

9	**References** Digital Product and Service Marketing Chaffey, D., & Ellis-Chadwick, F. (2019). Digital marketing: strategy, implementation & practice. Pearson UK.. Chaffey, D., & Smith, P. R. (2017). Digital marketing excellence: planning, optimizing and integrating online marketing. Routledge. Homburg, C../Stock-Homburg, R. (2011): Theoretische Perspektiven der Kundenzufriedenheit, in: Homburg, C. (Hrsg.), Kundenzufriedenheit: Konzepte, Methoden, Erfahrungen, Wiesbaden, 8. Auflage. Stock-Homburg, R. (2011), Der Zusammenhang zwischen Mitarbeiter- und Kundenzufriedenheit: Direkte, indirekte und moderierende Effekte, Wiesbaden, 5. Auflage. Digital Innovation Marketing: Stock-Homburg, R. M., Heald, S. L., Holthaus, C., Gillert, N. L., & von Hippel, E. (2021). Need-Solution Pair Recognition by Household Sector Individuals: Evidence, and a Cognitive Mechanism Explanation. Research Policy, 50(8), 104068. Source: Trott, P. (2012), Innovation Management and New Product Development. 5th edition, Harlow. Hauser, J., Tellis, G. J., Griffin, A. (2006), Research on Innovation: A Review and Agenda for Marketing Science, Marketing Science, 25(6), 687-717. von Hippel, E. (2005), Democratizing Innovation, Cambridge, Kapitel 9-11. Garcia, R., & Calantone, R. (2002). A Critical Look at Technological Innovation Typology and Innovativeness Terminology: A Literature Review. Journal of Product Innovation Management, 19(2), 110-132. Leifer et al. (2000), Radical Innovation: How Mature Companies can Outsmart Upstarts , Harvard Business School Press , Boston Further literature will be announced in the lecture.

Courses

Course nr.	Course name		
01-17-0005-vu	Digital Product and Service Marketing		
Instructor		**Type**	**SWS**
Prof. Dr. Dr. Ruth Stock-Homburg		Lecture and practice	2
Course nr.	**Course name**		
01-17-0007-vu	Digital Innovation Marketing		
Instructor		**Type**	**SWS**
Prof. Dr. Dr. Ruth Stock-Homburg		Lecture and practice	2

Module name Master Seminar					
Module nr. 01-01-0M05	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 150 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner**		

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

Courses

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

Module name					
Project Management					
Module nr. 01-19-1350/6	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language English			**Module owner** Prof. Dr. rer. pol. Andreas Pfnür		

1	**Teaching content** Project management I: Basics of planning and decision making for projects, project goals, generation of project alternatives, separation basics in configuration management, project definition, program - portfolio, stake-holder management and communication, quality management, scope and change management, human re-sources management for projects / project managers Project management II: Strategic goals, separation and linking of projects; project portfolio planning; multi project management; organizational structures of multi project management; tools to select project alterna-tives; tools for project controlling; project management as professional service.
2	**Learning objectives** After the course students are able to • understand the strategic goals of project management, the methods of choosing realization alternatives and the methods of project controlling • understand the various subsystems of project management (e.g. Configuration Management, Human Resource Management, Stakeholder Management, Risk Management) • understand the principles, methods and organization of multi project management
3	**Recommended prerequisites for participation** Prerequisites: none Previous Knowledge: see initial skills
4	**Form of examination** Module exam: • Module exam (Technical examination, Oral/written examination, Default RS) Supplement to Assessment Methods Oral/written: Type and duration of exam are announced by the beginning of the course Written: exam (duration 60 - 90 minutes) Oral: team or individual exam (duration 15 - 20 minutes per participant)
5	**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. Wirtschaftsingenieurwesen, M.Sc. Wirtschaftsinformatik, M.Sc. Entrepreneurship and Innovation Management, M.Sc. Logistics and Supply Chain Management
8	**Grade bonus compliant to §25 (2)**
9	**References** Project Management Institute (2013): A Guide to the Project Management Body of Knowledge (PMBOK Guide) 5th Edition Further literature will be announced in the lecture.
Courses	

<table>
<tr><td rowspan="2"></td><td>Course nr.
01-19-0001-vu</td><td colspan="3">Course name
Project Management I</td></tr>
<tr><td colspan="2">Instructor</td><td>Type
Lecture and practice</td><td>SWS
2</td></tr>
<tr><td rowspan="2"></td><td>Course nr.
01-19-0003-vu</td><td colspan="3">Course name
Project Management II</td></tr>
<tr><td colspan="2">Instructor
Prof. Dr. Alexander Kock</td><td>Type
Lecture and practice</td><td>SWS
2</td></tr>
</table>

Module name Financial Accounting and Reporting					
Module nr. 01-14-1B01	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr. rer. pol. Reiner Quick		

1	**Teaching content** Financial Accounting: Fundamentals of accounting and bookkeeping, inventory, balance sheet, recording of assets and debt, recording of expenses and revenues, selected transactions (sales and purchases, non-current assets, current assets, accruals, wage and salary, distribution of earnings), annual closing entry. Financial Reporting: Fundamentals of accounting based on the rules of the German Commercial Code (HGB), accounting concepts, purpose of accounting, bookkeeping, inventory, recognition and measurement of assets and liabilities, income statement, notes, management report.
2	**Learning objectives** After the course students are able to • understand the core principles of bookkeeping, inventory and preparation of the balance sheet • book stocks and profit • solve specific bookkeeping problems in the fields of sales and purchases, non-current and current assets, accruals, wage and salary, distribution of earnings • understand of the steps prior to the preparation of annual financial statements according to the German Commercial Code (HGB) • analyze of the recognition and measurement of assets and liabilities • understand of Income statements, notes and management reports • solve accounting cases in the context of the German Commercial Code (HGB)
3	**Recommended 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) • Module exam (Study achievement, Oral/written examination, Duration: 45 Min., Default RS) Supplement to Assessment Methods: The academic achievement needs to be passed to take part in the module exam.
5	**Prerequisite for the award of credit points** Passing the Examination
6	**Grading** Module exam: • Module exam (Technical examination, Written examination, Weighting: 2) • Module exam (Study achievement, Oral/written examination, Weighting: 1)
7	**Usability of the module** B.Sc. Wirtschaftsingenieurwesen, B.Sc. Wirtschaftsinformatik
8	**Grade bonus compliant to §25 (2)**
9	**References** Quick, R./ Wurl, H.-J: Doppelte Buchführung, 2. Aufl., Wiesbaden: Gabler. Quick, R./Wolz, M.: Bilanzierung in Fällen. 4. Auflage. Schäffer Poeschel, Stuttgart Further literature will be announced in the lecture.

Courses				
	Course nr. 01-14-0001-vu	**Course name** Bookkeeping		
	Instructor Prof. Dr. rer. pol. Reiner Quick		**Type** Lecture and practice	**SWS** 2
	Course nr. 01-14-0003-vu	**Course name** Financial Accounting		
	Instructor Prof. Dr. rer. pol. Reiner Quick		**Type** Lecture and practice	**SWS** 2
	Course nr. 01-14-0001-tt	**Course name** Bookkeeping		
	Instructor Prof. Dr. rer. pol. Reiner Quick		**Type** Tutorial	**SWS** 1
	Course nr. 01-14-0003-tt	**Course name** Financial Accounting		
	Instructor Prof. Dr. rer. pol. Reiner Quick		**Type** Tutorial	**SWS** 1

Module name					
Management of value-added networks					
Module nr. 01-12-0B02	**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. rer. pol. Ralf Elbert		

1 Teaching content

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

2 Learning objectives

After the course students are able to

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

3 Recommended 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

Further literature will be announced in the lecture.

Courses

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

Module name Human Resources Management					
Module nr. 01-17-1036	**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. Dr. Ruth Stock-Homburg		

1 Teaching content

- Basics of human resource management
- Selected approaches to the design of employee flow systems
- Selected approaches to the design of reward systems
- Embedding of personnel management in the company
- New challenges of personnel management (e.g. digital work, robots as team colleagues, boreout)

2 Learning objectives

After the courses the students are able to

- understand and explain the fundamentals of human resource management.
- classify and critically evaluate selected approaches to the design of employee flow systems.
- classify and critically evaluate selected approaches to the design of reward systems.
- understand and explain new challenges in human resource management.
- classify the concepts discussed with regard to their relevance in corporate practice.

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

Compulsory Reading:
Stock-Homburg, R. & Groß, M. (2019), Personalmanagement: Theorien - Konzepte - Instrumente, 4. Auflage, Wiesbaden. Kapitel: 1, 3-6, 8-9, 12-13, 15,18-19.

Further Reading:
Baruch, Y. (2004), Managing Careers: Theory and Practice, Harlow.
Gmür, M., Thommen, J.-P. (2007), Human Resource Management: Strategien und Instrumente für Führungskräfte und das Personalmanagement, 2. Auflage, Zürich.
Mondy, R. W. D., & Martocchio, J. J. (2015). Human Resource Management, Global Edition. Pearson Education Limited.
Junker, A. (2018). Grundkurs Arbeitsrecht (17., neu bearbeitete Auflage). Verlag C.H. Beck.

Further literature will be announced in the lecture.

Courses

Course nr.	**Course name**		
01-17-0003-vu	Human Ressources Management		
Instructor		**Type**	**SWS**
Prof. Dr. Dr. Ruth Stock-Homburg		Lecture and practice	3

Module name Sustainable Management					
Module nr. 01-42-0M02/6	**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. jur. Janine Wendt		

1 Teaching content

Sustainability and corporate law - definitions and implications of sustainability: conceptualisation through the Brundtland Report as well as the Rio Earth Summit and follow-up summits; conceptual consolidation and Agenda 2030; central features of the concept of sustainability - corporate law as an obstacle or promoter of sustainability - significance of the corporate governance discussion - the shareholder value model: criticism and alternative models - corporate law promotion of sustainability: sustainability and executive remuneration; social responsibility (CSR), supply chain legislation in Germany and Europe; climate change litigation; sustainable finance and social entrepreneurship

Sustainability Management: Sustainability and Corporate Social Responsibility: Approaches, Opportunities and Challenges for Companies - Sustainability-oriented Management Systems: Quality, Environmental and Energy Management Systems as well as Social Standards and Social Responsibility - Integrated Management Systems - Sustainability Reporting - Sustainability Supply Chain Management - Relations to Corporate Governance and Compliance Management - Implementation of Sustainability Management in Companies: Guest lectures from corporate practice

2 Learning objectives

After the course students are able to

- distinguish and derive different definitions and conceptualisations of sustainability,
- assess whether corporate law can be judged as an obstacle or a promoter of sustainability,
- present criticism and alternative models of the shareholder value model,
- present different approaches to corporate law promotion of sustainability, including regulation of executive remuneration, social responsibility (CSR) and supply chain legislation in Germany and Europe,
- discuss the main features of climate change litigation,
- classify Sustainable Finance and Social Entrepreneurship,
- understand the tasks, objectives and problems of sustainability management in companies
- assess the design, opportunities and challenges of management systems
- assess the possibilities and limitations of the different instruments of quality and environmental management
- critically analyze approaches from business practice..

3 Recommended prerequisites for participation

Prerequisites: none
Previous Knowledge: see initial skills

4 Form of examination

Module exam:

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

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

5 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. Wirtschaftsingenieurwesen, M.Sc. Wirtschaftsinformatik, M.Sc. Entrepreneurship and Innovation Management, M.Sc. Logistics and Supply Chain Management
8	**Grade bonus compliant to §25 (2)**
9	**References** Mittwoch, Nachhaltigkeit und Unternehmensrecht (2022) Ahsen, A. von; Bradersen, U.; Loske, A.; Marczian, S. (2015): Umweltmanagementsysteme. In: Kaltschmitt, M.; Schebek, L. (Hrsg.): Umweltbewertung für Umweltingenieure, Berlin, Heidelberg, S. 359-402. Baumast, A.; Pape, J. (Hrsg.): Betriebliches Nachhaltigkeitsmanagement, 2. Aufl., Stuttgart 2022 Further literature will be announced in the lecture.

Courses

Course nr.	Course name		
01-14-0010-vu	Sustainability Management		
Instructor		**Type**	**SWS**
		Lecture and practice	2
Course nr.	**Course name**		
01-42-0006-vu	Sustainability and Corporate Law		
Instructor		**Type**	**SWS**
Prof. Dr. jur. Janine Wendt		Lecture and practice	2

2.10 Optional Subjects AIS-TE: Technology

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** BSc 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 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** BSc ETiT, BSc 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. Klaus Hofmann, Prof. Ph.D. Thomas Burg, Prof. Dr.-Ing. Tran Quoc Khanh, Prof. Dr. Mario Kupnik		Project seminar	4

Module name					
Product Development Methodology II					
Module nr. 18-sa-1020	**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. Klaus Hofmann		

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, B.Sc iST, B.Sc. WI-etit, M.Sc MedTec
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. Klaus Hofmann, Prof. Ph.D. Thomas Burg, Prof. Dr.-Ing. Tran Quoc Khanh, Prof. Dr. Mario Kupnik		Project seminar	3

Module name Product Development Methodology III					
Module nr. 18-sa-2010	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Ph.D. Thomas Burg		

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, M.Sc iST, M.Sc. MedTec, M.Sc. WI-etit
8	**Grade bonus compliant to §25 (2)**
9	**References** Script: Development Methodology (PEM)

Courses

Course nr.	Course name		
18-sa-2010-pj	Product Development Methodology III		
Instructor Prof. Dr.-Ing. Klaus Hofmann, Prof. Ph.D. Thomas Burg, Prof. Dr.-Ing. Tran Quoc Khanh, Prof. Dr. Mario Kupnik		**Type** Project seminar	**SWS** 3

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, M.Sc iST, M.Sc. MedTec
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. Klaus Hofmann, Prof. Ph.D. Thomas Burg, Prof. Dr.-Ing. Tran Quoc Khanh, Prof. Dr. Mario Kupnik		Project seminar	3

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** BSc ETiT, MSc MEC, MSc WI-ETiT
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, M.Sc. Niko Faul		Lecture	2

	Course nr. 18-bu-1010-ue	**Course name** Foundations of Precision Engineering		
	Instructor Prof. Ph.D. Thomas Burg, M.Sc. Niko Faul		**Type** Practice	**SWS** 1
	Course nr. 18-bu-1010-pr	**Course name** Foundations of Precision Engineering Lab		
	Instructor Prof. Ph.D. Thomas Burg		**Type** Internship	**SWS** 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** MSc ETiT, MSc WI-ETiT, MSc MEC, MSc Medizintechnik
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		**Type** Lecture	**SWS** 2
	Course nr. 18-kn-2120-ue	**Course name** Sensor Technique		
	Instructor Prof. Dr. Mario Kupnik		**Type** Practice	**SWS** 1

<table>
<tr><td colspan="6">Module name
Introduction 3D-Printing and Additive Manufacturing</td></tr>
<tr><td>Module nr.
16-17-3253</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 2. Semester</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr. Edgar Dörsam</td></tr>
</table>

1 Teaching content

Terminology, process chains, process types, industrial technologies, materials, design, engineering strength, data workflow and data models, potential

2 Learning objectives

On successful completion of this module, students should be able to:
1. Explain all terms of 3D-Printing and Additive Manufacturing.
2. Follow through with a systematic comparison of alternative production methods.
3. Analyze the influence of the materials on the quality of products.
4. Explain the design demands of 3D-parts.
5. Distinguish important aspects of CAD models and voxel models.
6. Show and discuss the potentials of Additive Manufacturing.

3 Recommended prerequisites for participation

Recommended modules are: 16-09-5010 Production Technology, 16-08-3241/5251 Material Science & Engineering I and II, 16-07-3011 Information and Communication Technology in Mechanical Engineering and 16-07-5020 Computer Aided Design.

4 Form of examination

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

Facultative (written 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

The current lecture notes can be downloaded from the moodle web pages while the semester is in session.

Courses

<table>
<tr><td>Course nr.
16-17-3253-vl</td><td colspan="2">Course name
Introduction 3D-Printing and Additive Manufacturing</td></tr>
<tr><td>Instructor</td><td>Type
Lecture</td><td>SWS
2</td></tr>
</table>

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** MSc ETiT, MSc Wi-ETiT, MSc MEC
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**
Dr.-Ing. Babak Zandi		Lecture	2

	Course nr.	Course name		
	18-kh-2010-pr	Lighting Technology I		
	Instructor		**Type**	**SWS**
	Dr.-Ing. Babak Zandi		Internship	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** MSc ETiT, MSc Wi-ETiT, MSc MEC
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	Internship	2

Module name Tutorial in 3D-Printing					
Module nr. 16-17-3264	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German			**Module owner** Prof. Dr. Edgar Dörsam		

1	**Teaching content** Classification of 3D printing in manufacturing technology; requirements; selection; workflow; independent realization of products; justification of approach and chosen production process
2	**Learning objectives** On successful completion of this module, students should be able to: 1. Identify application areas for 3D printing. 2. Choose a suitable 3D printing production process to manufacture parts. 3. Modify part geometry regarding the specific production process. 4. Use common software from the 3D printing workflow. 5. Analyze typical printing errors and modify print parameters. 6. Justify the chosen approach in written form.
3	**Recommended prerequisites for participation** Participation of lecture „Introduction 3D-Printing and Additive Manufacturing“
4	**Form of examination** Module exam: • Module exam (Technical examination, Special form, Default RS)
5	**Prerequisite for the award of credit points** Passing the final module examination
6	**Grading** Module exam: • Module exam (Technical examination, Special form, Weighting: 100 %)
7	**Usability of the module**
8	**Grade bonus compliant to §25 (2)**
9	**References** Gebhardt, Andreas. 3D-Drucken: Grundlagen und Anwendungen des Additive Manufacturing (AM). Carl Hanser Verlag GmbH Co KG, 2014. http://www.hanser-elibrary.com/isbn/9783446442382

Courses

Course nr.	**Course name**		
16-17-3264-tt	Tutorial in 3D-Printing		
Instructor		**Type** Tutorial	**SWS** 4

<table>
<tr><td colspan="6">Module name
Project Seminar Spintronic Devices</td></tr>
<tr><td>Module nr.
18-me-2030</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. rer. nat. Markus Meinert</td></tr>
</table>

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** MSc etit, MSc iCE, BSc/MSc iST, MSc MEC
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