Technology
Arts Sciences
TH Köln

Faculty 07 of Information, Media and Electrical Engineering

Master Communication Systems and Networks PO3

Module Manual

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The most recent version of this handbook can be found here:
https://f07-studieninfo.web.th-koeln.de/mhb/current/en/MaCSN2020.html

1. Program Description

The ever-increasing interaction of hardware and software solutions and the networking of systems characterize the economic and technological developments in the computer industry and telecommunications sector. The Communication Systems and Networks degree program offers students the opportunity to understand and design the complex interrelationships of modern and future communication systems and services. A special feature of the course is the holistic view of communication systems from the system level to the network level, including the current security requirements for such systems. By choosing from two specialization profiles, Communication Systems and Networks and Security, students have the opportunity to acquire in-depth knowledge and skills in one of these areas, depending on their inclinations. The course is taught almost exclusively in English. It is therefore also aimed at international students with English language skills.

Occupational fields

The planning, development and customer-specific adaptation of new communication technology systems and networks are at the heart of professional activities. The generally strong demand for communication and information technology services in practically all sectors of the economy opens up numerous prospects in many industries. In addition to large companies in the mobile communications and telecommunications sector, there are manufacturers and suppliers of telecommunications equipment and facilities, network operators and broadcasters, manufacturers of consumer electronics equipment, machine and plant manufacturers, the automotive industry and its suppliers. should be mentioned. Work as a research assistant at scientific and public institutions and research facilities with the possibility of a doctorate is also envisaged.

Expectations of applicants

In addition to the formal admission requirements according to §3 of the examination regulations, students are expected to show a high degree of motivation, commitment, personal responsibility and resilience in the organization and implementation of their studies.

Study program

The Master's program is offered by the Institute of Communications Engineering of the Faculty of Information, Media and Electrical Engineering at the TH Köln in cooperation with the Department of Computer Science at the Bonn-Rhein-Sieg University of Applied Sciences in St. Augustin. It is characterized by a practice-oriented, professionally qualifying education. The modular structure of the course and the assessment of modules and courses according to the European Credit Transfer System (ECTS) facilitate international student exchange. The course is worth a total of 90 ECTS points. A large number of subjects are taught in English. The application-oriented Master's degree course in Communication Systems and Networks is designed for a standard period of study of three semesters, including the completion of the Master's thesis, and leads to a Master of Science degree. Through double degree agreements with the Universidad Polytécnico de Valéncia and the Universidad Polytécnico de Madrid, students have the opportunity to obtain a Master's degree from the TH Köln and a renowned Spanish university with little additional effort. The programs there are also largely offered in English.

Study requirements

- Bachelor's or Diplom degree in a computer science program, a mathematical-scientific or engineering program in the field of information and communication technology with at least 210 ECTS points and a final grade of better than 2.3.
- In the case of degrees with fewer than 210 ECTS points, the degree program can be accepted through additional achievements in the form of internships and/or courses.

Start of studies

The course usually begins in the summer semester. It is possible to start in the winter semester.

2. Graduate Profile

Graduates of the M. Sc. Communication Systems and Networks degree program are able to analyze, design and further develop highly complex communication systems and network technologies at an advanced scientific level. They assume responsibility in research, development, system integration and technological management -- both nationally and internationally. The course is aimed at qualified computer science and engineering graduates and clearly stands out from undergraduate courses due to its research-oriented, international and interdisciplinary focus.

The Master's degree course in Communication Systems and Networks is a scientifically sound, strongly application-oriented course in the field of information and communication technology. Unlike a Bachelor's degree, the CSN program focuses on the conceptual depth, cross-system responsibility and innovative design of future information and communication systems and networks.

Students acquire in-depth, interdisciplinary specialist knowledge in the areas of:

- Communication systems, network technologies and signal processing
- Information theory, information security and cryptography, embedded systems, AI-supported networks
- Distributed systems, IoT architectures, mobile networks, multimedia communication

The study program is characterized by

- complete delivery in English and international orientation,
- selectable profile specializations (“Communication Systems” or “Networks and Security”),
- close integration of research-based project work,
- double-degree programs with partner universities in Spain, and
- sound preparation for management positions and/or a doctorate.

Graduates of the degree program develop a profile specific to the Master's degree in the following areas:

- They design, implement and evaluate complex systems of modern communication and network technology, taking into account economic, ecological and ethical aspects.
- You are proficient in scientific methods at a high level and can work on research questions in a structured manner - also with a view to a later doctorate.
- Through projects such as the research project and the Master's thesis, they develop skills in scientific analysis, interdisciplinary teamwork and innovation.
- They are able to take on responsibility in dynamic, technology-driven environments such as mobile communications, IT infrastructure, IoT, broadcasting technology or cloud/edge computing.
- You have the intercultural and communication skills to work effectively in international teams and communicate complex issues convincingly.
- They are prepared to classify new technical developments, assess their relevance and independently acquire new skills - lifelong learning is a central component of their professional identity.

3. Fields of Action

Central fields of activity in the degree program are development and design, research and innovation, leadership and management as well as quality assurance and testing. The profile module matrix shows which fields of activity are addressed by which modules.

Development and Design

Interdisciplinary development and testing of algorithms, circuits, software, devices, communication and media technology systems as well as complex computer, communication and embedded systems.

Research and innovation

Perform scientific research work and apply and expand scientific knowledge, from basic research to industrial research, with the qualification for doctoral studies.

Leadership and management

Assume technical leadership and project responsibility, including the coordination and management of working groups and internationally distributed teams, as well as the management of planning and manufacturing processes, project controlling and product management.

Quality assurance and testing

Carrying out quality controls and tests for products and processes, using measurement and testing technologies and coordinating certification processes.

4. Competencies

The modules of the degree program train students in different competencies, which are described below. The [Profile Module Matrix] (#Module Matrix) shows which competences are competencies are addressed by which modules.

Development and design of complex systems

Ability to design and implement large systems, taking into account electrical, software, mechanical and optical aspects, based on a thorough requirements analysis from a technical, economic, ecological and social point of view.

Testing and evaluation of complex systems

Plan, perform and analyze tests to verify and validate these systems, including consideration of user perspectives and technical-economic aspects.

Scientific work and research

Mastery and application of scientific methods, including the ability to research, evaluate and cite relevant literature, and to formulate and present results.

Project management and teamwork

Skills in organizing, managing and supervising projects and teams, even under uncertain conditions, and in making professional and organizational decisions.

Self-organization and self-taught skills

Identification of personal skills, efficient time management and the ability for self-directed learning.

Communication and intercultural competence

Ability to present and defend scientific and technical results convincingly in both German and English, including international and interdisciplinary contexts.

Technical and scientific fundamentals

Comprehensive and in-depth STEM subject knowledge and its application to real-world and theoretical problems.

Sustainability and social responsibility

Evaluate and develop sustainable and socially responsible technologies, including consideration of ethical values.

Analysis, simulation and abstraction

Ability to analyze complex systems, abstract key features and solve problems based on models.

Leadership and decision-making responsibility

Assume responsibility in technical management tasks, develop solution strategies for complex tasks.

Applying ethical values and principles in practice

Incorporating social and ethical considerations into technical decisions and design processes.

Integrative thinking and acting in interdisciplinary teams

Coordinating and integrating contributions from different disciplines to solve complex tasks.

Innovation and creativity

Developing new solutions and concepts to overcome technical challenges.

5. Study Plans

The following are studyable study plans. Other study plans are also possible. Please note, however, that each module is usually only offered once a year. Please also note that several modules may have to be selected in a particular semester and elective catalogs in order to obtain the total ECTS credit points shown.

5.1 Regelstudium

Sem.	Abbr.	Name	Catalog (WB) Elective Mandatory (PF)	ECTS
1	HIM	Advanced Mathematics	PF	5
	BSN	Fundamentals of System and Network Theory	PF	5
	PFM	Profile Module	WB	10
	EL1	Electives Catalog 1	WB	10
	PM	Project Management	PF	5
2	PFM	Profile Module	WB	10
	RP	Research Project	PF	10
	EL2	Electives Catalog 2	WB	5
	EL3	Elective 3	WB	5
3	MAA	Masterarbeit	PF	27
	KOLL	Kolloquium zur Masterarbeit	PF	3

6. Modules

The modules of the degree program are described below in alphabetical order. If the course recognized for the module has a different ID, this different ID is indicated in brackets after the module ID.

6.1 ACC - Advanced Channel Coding

Module ID	ACC
Module Name	Advanced Channel Coding
Type of Module	Elective Modules
Recognized Course	ACC - Advanced Channel Coding
ECTS credits	5
Language	englisch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Uwe Dettmar
Lecturer(s)	Prof. Dr. Uwe Dettmar (Professor Fakultät IME)

Learning Outcome(s)

> What? Designing and rating of systems for the reliable transmission of data over distorted channels and storage of data for data at rest and data in motion
> How? By applying results from information theory and applying methods and algorithms for error correcting codes using existing simulations tools, self written programms, and studying existing systems.
> What for? To be able to design, select, use and apply actual and future digital communication systems for reliable data transmission, and to rate their performance.

Module Contents

Lecture / Exercises

The underlying concept of this module is a combination from lecture and tutorial. After a lecture block of approximately 20 minutes) the subjects taught are actively trained using Matlab/Octave and Python programs.

Syllabus:
- Introduction
- Basic terms and definitions
- short history of channel coding
- System and channel models
- Review of binary error correcting block and convolutional Codes
- Generator and Parity check matrices,
- decoding principles, Trellis and Viterbi Algorithm
- Some principles on Information Theory
- Channel coding theorem
- Channel capacity and example calculations
- Cyclic Codes, Reed Solomon Codes
- Encoding and Decoding, Euklidean and Berlekamp-Massey -Algorithm for Decoding
- Basics on LDPC, Polar, and TURBO Codes
- iterative decoding, Sum Product Algorithm
- Recursive Convolutional Codes
- Performance comparison
- Basics on Space Time Coding
- Channel Model, Capacity improvement, Alamouti Scheme, STBC and STTC and their decoding

These subjects are presented during the lecture. Students shall deepen their knowledge by self-study of literature and internet ressources and discuss their results in small learning groups as a teamwork.

By the help of small exercises and programs during the presence time, students are able to actively train their knowledge. More extensive problems are solved and discussed in the second part of the course to activate the student's capabilities to solve relevant problems.

Students further learn
- to analyze communication systems and to estimate their performance
- to compare and rate algorithms and methods
- to apply their knowledge to technical problems

Lab

Existing simulation Tools like, e.g., the Matlab Communications Toolbox or AFF3CT (aff3ct.github.io) are used to:
- test theoretical results from lecture and tutorial
- implement algorithms for error control coding
- simulate BER and rate the performance, compare schemes
- adapt programs to solve equivalent problems
- become familiar with standard simulations tools
- train cooperation in small teams

Students learn to generate, check, present, and discuss performance results for FEC codes. They need to search for and to study scientific literature as background sources for their simulations. Teams of students get different code families to study. Results are presented to the whole group.

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Lab
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS

Self-Study	105 Hours
Recommended Prerequisites	▪ Modul HIM: Grundkenntnisse zur linearen Algebra, der Algebra in endlichen Zahlenkörpern, der Stochastik und der digitalen Kommunikationstechnik aus den vorangegangenen Bachelorstudiengängen. Da das Fach im ersten Fachsemster des Masters gewählt werden kann, können keine belastbaren Kenntnisse aus dem Fach HIM verpflichtend vorausgesetzt werden, auch wenn sie hilfreich wären. ▪ basics in linear algebra basics in stochastics good programming skills
Mandatory Prerequisites	▪ Lab requires attendance in the amount of: 2 Praktikumstermine und 1 Präsentation ▪ Participation in final examination only after successful participation in Lab
Capacity-limited admission	no
Recommended Literature	▪ R. E. Blahut. Algebraic Codes for Data Transmission. Cambridge University Press, Cambridge, 2003. ▪ S. Lin and D. J. Costello. Error Control Coding. ISBN 0-13-042672-5. Prentice-Hall, 2004 ▪ T. M. Cover and J. A. Thomas. Elements of Information Theory. Wiley, New Jersey, 2006 ▪ A. Neubauer. Kanalcodierung. Schlembach, Wilburgstetten, 2006. ▪ R. Roth. Introduction to Coding Theory. Cambridge, second edition, 2006 ▪ B. Sklar. Digital Communications. Prentice Hall PTR, Upper Saddle River, New Jersey, 2001
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2 ▪ PFM - Profile Module
Included in Specialization	CS - Communication Systems
Use of the Module in Other Study Programs	▪ ACC in Master Communication Systems and Networks PO4 ▪ ACC in Master Elektrotechnik und Informationstechnik PO1 ▪ ACC in Master Technische Informatik PO3 ▪ ACC in Master Informatik und Systems-Engineering PO1
Permanent Links to Organization	ILU course page
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.2 AMC - Advanced Multimedia Communications

Module ID	AMC
Module Name	Advanced Multimedia Communications
Type of Module	Elective Modules
Recognized Course	AMC - Advanced Multimedia Communications
ECTS credits	5
Language	englisch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Andreas Grebe
Lecturer(s)	Prof. Dr. Andreas Grebe (Professor Fakultät IME)

Learning Outcome(s)

> What?
> Understanding service requirements, driven by heterogeneous services, in All-IP networks, and how to design, implemnt and evaluate quality-of-service (QoS) and quality-of-experience (QoE) mechanisms. Competences to evaluate, analyze, design, implement and test multiservice Ip networks with heterogeneous service requirements.
> How?
> Based on Bachelor-level competences on IP networking and services, students learn different application (service) requirements from filetransfer to streaming and how to separate and fulfill these requirements in IP networks. In a small team and organized as semester project, students develop their own multiservices networks, optionally based and on existing systems, and learn how to design, implementnt and anlysze their own multiservice network solution.
> What for?
> To be able to design, analyze, select, use and apply actual and future network technologies, based on All-IP networks concepts for enterprise networks, telecommunication networks and mobile networks.

Module Contents

Lecture / Exercises

> Content for multimedia applications, encoding of multimedia data, integration of data, audio and video, multimedia traffic requirements, multimedia transport protocols, RTP and MPEG-TS, traffic modeling burst silence model, quality of service (QoS), multiservice networks, IntServ, RSVP, DiffServ, ToS and DSCP, Traffic Classification, Traffic Measurement, Traffic Shaping, Network Scheduling, Queueing (FIFO, RR, WRR, WFQ, CB-WFQ, PQ, LLQ), Congestion Avoidance (RED, WRED, CB-WRED), Quality-of-Exiperience (QoE), MOS Scale, Error Detection, Error Correction, FEC, Interleaving, Jitter Buffer.

> Students evaluate technologies and network architectures of multiservice networks; they analyse requirements of Multimedia services and systems, design architectures for multiservice networks, implement multiservice networks, and analyze Multimedia communication protocols and their performance metrics.

Lab

> Fundamental knowledge of multiservice networks or multimedia applications in All-IP networks including planning, implementation and evaluation of services. Protocol analysis for functional analysis, performance analysis and troubleshooting.

> Students evaluate requirements of Multimedia services, and necessary methods for QoS in multiservice networks. They plan and implement IP Multimedia environments as team project,
> and test QoS performance measures. They are competent in functional analysis and troubleshooting by deep packet inspection (DPI) protocol analysis. They evaluate the performance of the Multimedia network or services in terms of timing, throughput, latency and delays, jitter, robustness in case of packet errors, and security aspects. Individual project proposals by students are wellcome.

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Lab

Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	▪ Modul BSN: Fundamentals of Networks and Protocols (typically Bachelor Level) Layered Communications and Protocol Stacks (ISO/OSI, IETF TCP/IP, IEEE), LAN, MAN, WAN, Fixed Line and Mobile Network Fundamentals, Data Link-Technologies (Ethernet, WiFi), IP-Networking (IPv4, IPv6), IP Routing Protocols (static Routes, RIP, OSPF, BGP), Transport Protocols (TCP (incl. Flow Control / Congestion Control), UDP) and Port Numbers, Application Protocols (HTTP, Request-Response Pattern, Publish-Subscribe Pattern). ▪ Bachelor-level knowledge of protocols and layer models, Internet protocols (UDP, TCP, IP, HTTP, FTP), IP addressing (IPv4, IPv6), routing techniques (IP routing, functionality of a router, routing protocols, RIP, OSPF), transmission systems and layer 2 protocols, Ethernet. Understanding distributed systems and applications, sockets and client/server programming, request-response patterns, publishg-subscribe patterns.
Mandatory Prerequisites	▪ Lab requires attendance in the amount of: 6 Meilensteintermine und Projektvorstellungen ▪ Participation in final examination only after successful participation in Lab
Capacity-limited admission	yes, according to approved request
Recommended Literature	▪ J. Kurose, K. Ross: Computer Networking: A Top-Down Approach, Global Edition, Prentice Hall, 7th ed., 2016 ▪ A. S. Tanenbaum, D. J. Wetherall: Computer Networks, Pearson , 5th ed., 2013 ▪ W. Stallings: Foundations of Modern Networking, Pearson Education, 2016 ▪ H. W. Barz, G. A. Bassett: Multimedia Networks, John Wiley & Sons, 2016 ▪ T. Szigeti, C. Hattingh, R. Barton, B. Kenneth: End-to-End QoS Network Design: Quality of Service for Rich-Media & Cloud Networks (2nd Edition) End-to-End QoS Network Design: Quality of Service for Rich-Media & Cloud Networks, Cisco Press, 2nd Ed. 2013 ▪ R. Steinmetz, K. Nahrstedt: „Multimedia Systems“, Springer 2004 ▪ R. Steinmetz, „Multimedia-Technologie“, Springer 2000
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2 ▪ PFM - Profile Module
Included in Specialization	▪ CS - Communication Systems ▪ N_S - Networks & Security
Use of the Module in Other Study Programs	▪ AMC in Master Communication Systems and Networks PO4 ▪ AMC in Master Technische Informatik PO3 ▪ AMC in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	22.10.2025, 11:22:18

6.3 AMS - Special Aspects of Mobile Autonomous Systems

Module ID	AMS
Module Name	Special Aspects of Mobile Autonomous Systems
Type of Module	Elective Modules
Recognized Course	AMS - Special Aspects of Mobile Autonomous Systems
ECTS credits	5
Language	englisch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Chunrong Yuan
Lecturer(s)	Prof. Dr. Chunrong Yuan (Professorin Fakultät IME)

Learning Outcome(s)

> Was: Das Modul vermittelt Kompetenzen zur Entwicklung von mobilen autonomen Systemen, insbesondere im Themenbereich der räumlichen Interpretation und Kognition für die sichere Navigation von unbemannten Roboter- und Fahrzeugsystemen sowie intelligente Interaktion und Kollaboration unter Menschen und Robotern.
> Womit: Die Dozentin vermittelt Wissen und Basisfertigkeiten in einem Vorlesungsteil und betreut parallel dazu praktische Projekte, wobei die Studierenden mittels forschenden Lernens technische Ansätze studieren und erproben, Prototypen aufbauen und testen, Ergebnisse präsentieren, sowohl technische als auch ethische und soziale Aspekte diskutieren, und das Ganze schriftlich dokumentieren.
> Wozu: Kompetenzen in der Entwicklung von mobilen autonomen Systemen sind essentiell für technische Informatiker*innen und Nachwuchs in verwandten Ingenieurberufen. Derartige Kompetenzen sind unentbehrlich für die Forschung, Entwicklung sowie technische Innovation. Das projektbasierte und forschende Lernen im Team hilft den Studierenden außerdem, sich mit relevanten ethischen und sozialan Aspekten zu beschäftigen, welche im Zusammenhang mit autonomen Systemen stehen.

Module Contents

Lecture

> Mobile autonomous systems
> Cognitive and behaviour-based robotics
> Environmental modelling and spatial cognition
> Interaction and navigation

Project

> Teamwork: Development of autonomous systems with cognitive capabilities and intelligent behaviours.
> Such cognitive capabilities include e.g.: Recognize objects with sensors, estimate their locations or movements, make 3D representations and interpretations or build a map of the environment etc.
> Intelligent behaviours can be demonstrated among others by such actions: Move and navigate autonomously without collision in unknown environments, fetch or transport objects for a special application, nature interactions and collaborations among human and robots.

Teaching and Learning Methods	▪ Lecture ▪ Project
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	34 Hours ≙ 3 SWS

Self-Study	116 Hours
Recommended Prerequisites	Capability of software and project development Knowledge of signal processing and mathematics
Mandatory Prerequisites	Project requires attendance in the amount of: 1 Präsentation
Capacity-limited admission	no
Recommended Literature	▪ Siegwart et.al.: Introduction to autonomous mobile robots, MIT Press, 2010
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ AMS in Master Communication Systems and Networks PO4 ▪ AMS in Master Technische Informatik PO3 ▪ AMS in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.4 ARP - Alternative Rechnerarchitekturen und Programmiersprachen

Module ID	ARP
Module Name	Alternative Rechnerarchitekturen und Programmiersprachen
Type of Module	Elective Modules
Recognized Course	ARP - Alternative Computer Architectures and Programming Languages
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. René Wörzberger
Lecturer(s)	Prof. Dr. Georg Hartung (Professor Fakultät IME im Ruhestand)

Learning Outcome(s)

> Die Studierenden lernen kennen, wenden an und analysieren verschiedene wichtige Konzepte von Rechnerarchitekturen und Programmiersprachen. Dazu wenden sie für jedes ausgewählte Konzept nach einer kurzen Vorstellung es auf ein selbstgewähltes Beispiel an, wozu sie sich weiteres Wissen über das Konzept erwerben müssen, und analysieden die Vor- und Nachteile des Konzepts in einem Bericht. Damit erlangen sie einen größeren Überblick über verfügbare Architekturen und Programmiersprachen für ihre spätere Tätigkeit als IT-Spezialist, Manager oder in der Forschung.

Module Contents

Lecture / Exercises

> Knowledge of the respective modeling method, programming procedure or architecture and its programming ("Topics"); practice of initial Topic skills in exercises.

Project

> Application of the topic to a self-selected task, analysis of the features of the topic on a concrete example, synthesis with own experiences, teamwork (processing in a small group)

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Project
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	- Experience in imperative programming languages, esp. C - Basic knowledge and experience in operating systems, esp. Linux - Basic knowledge and experience in software engineering - Basic knowledge of computer design and operation, including operation of important digital components - Basic knowledge of formal languages and automata theory
Mandatory Prerequisites	Project requires attendance in the amount of: 4 Termine
Capacity-limited admission	no

Recommended Literature	▪ Jensen, K., Kristensen, L.M.: Coloured Petri Nets ▪ Nilsson, U.; Maluszynski, J.: Logic, Programming and Prolog ▪ T. Eiter, G. Ianni, T. Krennwallner: 'Answer Set Programming: A Primer' in: Reasoning WEB Semantic Technologies for Information Systems ▪ Steve Klabnik and Carol Nichols: The Rust Programming Language ▪ William Gropp et al.: Using Advanced MPI / Modern Features of the Message Passing Interface, MIT Press ▪ Gerassimos Barlas Multicore and GPU Programming - An Integrated Approach Morgan Kaufmann Publ., Inc.
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ ARP in Master Communication Systems and Networks PO4 ▪ ARP in Master Technische Informatik PO3 ▪ ARP in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.5 AVT - Audio- und Videotechnologien

Module ID	AVT
Module Name	Audio- und Videotechnologien
Type of Module	Elective Modules
Recognized Course	AVT - Audio and Video Technologies
ECTS credits	5
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr.-Ing. Klaus Ruelberg
Lecturer(s)	Prof. Dr.-Ing. Klaus Ruelberg (Professor Fakultät IME)

Learning Outcome(s)

> Was:
> Audio- und Videotechnologien kommen in vielfältiger Weise in der Medienindustrie zum Einsatz. Die Mediendistributionskette, die im Rahmen der LV als exemplarische Anwendung herangezogen und analysiert wird, umfasst verschiedene Technologien wie Datenkompression, Audio- und Videosignalverarbeitung Fehlerschutzmechanismen, digitale Modaluationsverfahren.
> Womit:
> Studierende durchdringen eigenständig ausgewählte Themengebiete der Audio- und Videotechnologien, bereiten diese auf und halten einen Fachvortrag.
> In einem in die LV integrierter Übungsblock entwickeln die Studierende eigenständig algorithmische Lösungskonzepte und setzen diese programmtechnsich um.
> Wozu:
> Die Studierenden können akuelle Verfahren zur Audio- und Videocodierung entwickeln und in Hard- und Software implementieren. Sie können Mediendistributionsketten planen, beurteilen und umsetzen sowie fachliche Führungs- und Projektverantwortung übernehmen

Module Contents

Lecture / Exercises

> Audio and video source coding
>
> Channel models, channel coding (FEC & digital modulation principles)
>
> Broadcast transmission systems (DVB - Digtal Video Broadcasting)
>
> implement audio and video coding methods in hard and software
>
> develope algorithms and methods for audio and videocoding
>
> delvelope and implement digital broadcasting systems

Exercises / Lab

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Exercises / Lab
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	57 Hours ≙ 5 SWS
Self-Study	93 Hours

Recommended Prerequisites	none
Mandatory Prerequisites	Exercises / Lab requires attendance in the amount of: 1 Termin
Capacity-limited admission	no
Recommended Literature	▪ Proakis, J. Salehi, M. (2007) Digital Communications. McGraw-Hill. ISBN 978-0072957167 ▪ Reimers, U. (2001) Digital Video Broadcasting. Springer Verlag. ISBN 978-3-662-04562-6
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ AVT in Master Communication Systems and Networks PO4 ▪ AVT in Master Medientechnologie PO3 ▪ AVT in Master Medientechnologie PO4 ▪ AVT in Master Technische Informatik PO3 ▪ AVT in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.6 AVV - Algorithmen der Videosignalverarbeitung

Module ID	AVV
Module Name	Algorithmen der Videosignalverarbeitung
Type of Module	Elective Modules
Recognized Course	AVV - Algorithms for video signal processing
ECTS credits	5
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr.-Ing. Klaus Ruelberg
Lecturer(s)	Prof. Dr.-Ing. Klaus Ruelberg (Professor Fakultät IME)

Learning Outcome(s)

> WAS:
> Studierende formulieren gemeinsam mit dem Dozenten eine Aufgabenstellung/Forschungsfrage im Bereich der Videosignalverarbeitung. Unter Anwendung wissenschaftlicher Methoden analysieren sie die Aufgaben- bzw. Fragestellung eigenständig und entwickeln algorithmische Lösungsansätze.
> WOMIT:
> Eine Recherche der wissenschaftlichen Literatur bildet die Basis für die Studierenden, um die Aufgabenstellung inhaltlich zu durchdringen und einordnen zu können. Verschiedene, als geignet erscheinende Lösungsansätze werden entwickelt und gegenübergestellt. Mithilfe geeigneter Entwicklungstools (z.B. Matlab) werden die entwickleten Algorithmen umgesetzt und bzgl. der Aufgabenstellung beurteilt. Die erzielten Ergebnisse des Projektes werden in einem Bericht zusammengefasst und im Rahmen eines Vortrages präsentiert.
> WOZU:
> Studierenden erhalten die Möglichkeit, sich tiefergehend mit einer wissenschaftlich/entwicklerischen Aufgabenstellung zu befassen.

Module Contents

Project

> The students are introduced to different algorithmic approaches of video signal processing and get an overview of current applications and questions.

> Analyzing, developing, implementing and evaluating algorithms for video signal processing

Teaching and Learning Methods	Project
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	12 Hours ≙ 1 SWS
Self-Study	138 Hours
Recommended Prerequisites	keine
Mandatory Prerequisites	Project requires attendance in the amount of: 70% der Praktikumstermine und 1 Präsentation (typischerweise 5 Termine)
Capacity-limited admission	no

Recommended Literature	▪ Signal, Image and Video Processing (Journal), Springer Verlag, Electronic ISSN 1863-1711 ▪ Machine Learning for Audio, Image and Video Analysis, Francesco Camastra, Alessandro Vinciarelli, Springer London, 2016, ISBN978-1-4471-6840-9
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ AVV in Master Communication Systems and Networks PO4 ▪ AVV in Master Medientechnologie PO3 ▪ AVV in Master Medientechnologie PO4 ▪ AVV in Master Technische Informatik PO3 ▪ AVV in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.7 BSN - Fundamentals of System and Network Theory

Module ID	BSN
Module Name	Fundamentals of System and Network Theory
Type of Module	Mandatory Module
Recognized Course	BSN - Basics on Systems and Networks
ECTS credits	5
Language	englisch
Duration of Module	1 Semester
Recommended Semester	1
Frequency of Course	every term
Module Coordinator	Prof. Dr. Rainer Kronberger
Lecturer(s)	▪ Prof. Dr. Rainer Kronberger (Professor Fakultät IME) ▪ Prof. Dr. Harald Elders-Boll (Professor Fakultät IME) ▪ Prof. Dr. Uwe Dettmar (Professor Fakultät IME)

Learning Outcome(s)

> Students learn the basics of communication systems and networks, by means of lectures, tutorials, exercises and practical laboratory experiments, so that they can later develop, design, analyze, measure and set up communication technology components, systems and networks.

Module Contents

Lecture

> Introduction to Digital Communication Systems and Networks
> Review of the Basics: Signals and Systems
> Review of the Basics: Probability Theory
> Representation of Bandpass Signals and Systems
> Signals, Noise, Electromagnetic Waves
> Wave Propagation
> Communication Components: Receiver and Transmitter
> Antennas
> Source Coding and Quantization
> Channel Coding and Cryptography
> Modulation
> OFDM
> Radio Standards and Mobile Communication Systems and Networks

Exercises / Lab

> Lab: Binary NRZ, IQ-Modulation and Demodulation
> Lab: Channel Coding and QPSK Modulation
> Lab: RF Signals

Teaching and Learning Methods	▪ Lecture ▪ Exercises / Lab
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	Basics in communications, electronics, information technologies
Mandatory Prerequisites	▪ Exercises / Lab requires attendance in the amount of: 3 Testattermine ▪ Participation in final examination only after successful participation in Exercises / Lab
Capacity-limited admission	no
Recommended Literature	▪ Tolga M. Duman, Fundamentals of Digital Communication Systems,Cambridge University Press, 2025 ▪ John Proakis and Masoud Salehi. Digital Communications. 5th. McGraw-Hill, 2007 ▪ Michael Rice. Digital Communications: A Discrete-Time Approach. Pearson Prentice Hall, 2009. ▪ James Kurose and Keith Ross. Computer Networking A Top Down Approach. 7th ed. Pearson, 2016. ▪ Andrew S. Tanenbaum, Nick Feamster, and David J. Wetherall. Computer Networks. 6th ed. Pearson, 2021. ▪ Ha H. Nguyen and Ed Shwedyk. A First Course in Digital Communications. Cambridge University Press, 2009. ▪ Upamanyu Madhow. Fundamentals of Digital Communication. Cambridge University Press, 2008.
Included in Elective Catalog	
Included in Specialization	
Use of the Module in Other Study Programs	▪ BSN in Master Communication Systems and Networks PO4 ▪ BSN in Master Elektrotechnik und Informationstechnik PO1
Permanent Links to Organization	Link for the learning platform
Specifics and Notes	
Last Update	21.9.2025, 19:12:28

6.8 CI - Computational Intelligence

Module ID	CI
Module Name	Computational Intelligence
Type of Module	Elective Modules
Recognized Course	CI - Computational Intelligence
ECTS credits	5
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Studiengangsleiter(in) Master Technische Informatik (Informatik und Systems-Engineering)
Lecturer(s)	Prof. Dr. Rainer Bartz (Professor Fakultät IME)

Learning Outcome(s)

Die Studierenden erarbeiten sich grundlegende Kenntnisse zur Theorie und Anwendung von Methoden der Computational Intelligence.
Die Studierenden kennen die gängigen Typen von Optimierungsaufgaben und können konkrete Aufgaben einordnen.
Die Studierenden kennen das Prinzip des Simplex-Algorithmus und können eine Problemstellung in die für ihn geeignete Standardform überführen und eine Lösung erarbeiten. Sie können lineare Probleme mit einem Simplex-Algorithmus lösen.
Die Studierenden können neuronale Netze einordnen und ihre Anwendbarkeit auf Problemstellungen bewerten. Sie können Lernverfahren klassifizieren und ihre Arbeitsweise beschreiben. Sie können nichtlineare Probleme der Modellbildung und Klassifizierung mit einem neuronalen Netz lösen.
Sie kennen die Methodik der Fuzzy Logik und können eine Problemstellung darauf abbilden und das resultierende Systemverhalten begründen. Sie können unscharf definierte Aufgaben mit Hilfe von Fuzzy Logik lösen.
Die Studierenden kennen die Arbeitsweise evolutionärer Algorithmen und können ihre Varianten einordnen. Sie können reale Problemstellungen in geeignete Repräsentationen umsetzen. Sie können Selektionsverfahren bewerten und geeignete Selektionsalgorithmen entwerfen. Sie können schwierige Probleme mit Heuristiken der evolutionären Algorithmen lösen.

Die Studierenden können mit üblichen Werkzeugen der Computational Intelligence umgehen.
Die Studierenden können Aufgaben in einem kleinen Team lösen.
Die Studierenden können Systemparameter variieren, Messreihen durchführen und Ergebnisse darstellen, bewerten und diskutieren. Sie können das Verhalten eines Systems bewerten und durch geeignete Modifikationen verbessern.
Die Studierenden können internationale wissenschaftliche Literatur analysieren, einordnen, in ihren Kontext stellen und präsentieren.

Module Contents

Lecture / Exercises

Optimization strategies
- classification of problems
- gradient algorithms
- simplex algorithm
- multiobjective optimization and Pareto approach

Artificial neural networks
- artificial neurons
- neural network structures
- training algorithms

Fuzzy logic
- fuzzification
- inference
- defuzzification

Evolutionary algorithms
- genome representations
- selection mechanisms
- recombination operators
- mutation operators

The students acquire fundamental knowledge on theory and applications of computational intelligence

The students know about typical classes of optimization tasks and how to map a specific problem to those classes

They know the simplex algorithm and can transform problems into the standard form to find the solutions

The students can classify artificial neural networks and determine their applicability for specific tasks

They can vary the parameters of neural networks and rate their impact on the results

They can classify training algorithms and understand the backpropagation algorithm

They know about the fuzzy logic approach, can apply it to specific problems and justify the resulting system behavior

The students know how evolutionary algorithms work and can distinguish the variants

They can transform a problem specification into a representation appropriate for an evolutionary algorithm

They can rate selection strategies and define suitable algorithms

The students can solve linear problems with the use of the simplex algorithm

They can apply artificial neural networks to solve problems of modeling and classification

They can define fuzzy logic systems to solve imprecise and vague tasks

They can solve difficult problems heuristically using evolutionary algorithms

Lab

Application of artificial neural networks to a classification task

Variation and multiobjective optimization of neural network parameters

Fuzzy-based closed loop control of a system with two inputs

The students are familiar with tools supporting computational intelligence

The students can vary system parameters, perform test series, and evaluate, present and discuss the results

The students are able to understand, present, analyze and discuss scientific publications

The students are able to solve problems in small teams

They can tackle optimization tasks in a structured and systematic way

They can rate the behavior of a system with regard to objectives and study and improve the behavior through parameter variations

They are able to cope with international scientific publications, understanding, presenting and discussing them in their context

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Lab
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	vector functions, gradient
Mandatory Prerequisites	Lab requires attendance in the amount of: 2 Termine
Capacity-limited admission	no
Recommended Literature	▪ Domschke W., Drexl A.; Einführung in Operations Research; Springer ▪ Zell, A.: Simulation Neuronaler Netze; Oldenbourg ▪ Nauck, D. et al.: Neuronale Netze und Fuzzy-Systeme; Vieweg ▪ Eiben, A.E., Smith, J.E.: Introduction to Evolutionary Computing; Springer ▪ Gerdes, I. et al.: Evolutionäre Algorithmen; Vieweg ▪ Grosse et al.: Taschenbuch der praktischen Regelungstechnik, Fachbuchverlag Leipzig
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ CI in Master Communication Systems and Networks PO4 ▪ CI in Master Technische Informatik PO3 ▪ CI in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	14.11.2025, 08:28:37

6.9 CSO - Computersimulation in der Optik

Module ID	CSO
Module Name	Computersimulation in der Optik
Type of Module	Elective Modules
Recognized Course	CSO - Computersimulation in der Optik
ECTS credits	5
Language	deutsch und englisch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Holger Weigand
Lecturer(s)	Prof. Dr. Holger Weigand (Professor Fakultät IME)

Learning Outcome(s)

> Kompetenz zum Aufbau, zur Analyse, zur Optimierung und Auslegung beleuchtungsoptischer Systeme unter Zuhilfenahme von Software basierend auf nicht-sequentiellem Raytrace.

> Kompetenz für Software-Entwicklung im Umfeld der Computersimulation (Makro-Programmierung mit Skript-Sprachen, z.B. zum Steuern des In- oder Outputs von Simulationen).

> Kompetenz zum Erwerb vertiefter Fertigkeiten im Bereich nicht-sequentieller Raytrace-Simulation durch eigenständiges Durcharbeiten von Literatur und Software-Dokumentation, sowie der Einbeziehung des technischen Supports der Software zu einer speziellen Thematik.

Module Contents

Lecture / Exercises

Lab

Project

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Lab ▪ Project
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	57 Hours ≙ 5 SWS
Self-Study	93 Hours
Recommended Prerequisites	
Mandatory Prerequisites	▪ Participation in final examination only after successful participation in Lecture / Exercises ▪ Participation in final examination only after successful participation in Lab
Capacity-limited admission	no

Recommended Literature	▪ W. T. Welford, R. Winston: High Collection Nonimaging Optics, Academic Press, 1989; G. Kloos: Entwurf und Auslegung optischer Reflektoren, Expert, 2007; Deutsche und US-Amerikanische Patentschriften; Datenblätter optischer und opto-elektronischer Komponenten; MIT Scheme Reference, Edition 1.62, 1996 (https://groups.csail.mit.edu/mac/ftpdir/scheme-7.4/doc-html/scheme_toc.html); H. Ramchandran, A. S. Nair: Scilab (a Free Software to Matlab), S. Chand, 2012; F. Thuselt, F. P. Gennrich: Praktische Mathematik mit MATLAB, Scilab und Octave, Springer 2013; T. Sheth: SCILAB: A Practical Introduction to Programming and Problem Solving, CreateSpace, 2016; C. Gomez: Engineering and Scientific Computing with Scilab, Birkhäuser, 1999;
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ CSO in Master Communication Systems and Networks PO4 ▪ CSO in Master Elektrotechnik PO3 ▪ CSO in Master Elektrotechnik und Informationstechnik PO1 ▪ CSO in Master Technische Informatik PO3 ▪ CSO in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	5.9.2025, 17:36:59

6.10 DBT - Digitale Bildtechnik

Module ID	DBT
Module Name	Digitale Bildtechnik
Type of Module	Elective Modules
Recognized Course	DBT - Digital Imaging
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Gregor Fischer
Lecturer(s)	Prof. Dr. Gregor Fischer (Professor Fakultät IME)

Learning Outcome(s)

> Was:
> Digitale Bildtechniken kommen in vielfältiger Weise in der Medienindustrie zum Einsatz. Die Bildkette digitaler Kameras, die im Rahmen der LV als exemplarische Anwendung herangezogen und analysiert wird, umfasst verschiedene Technologien wie Farbbildtechnik, HDR-Bildtechnik oder bildtechnische Verfahren.
>
> Womit:
> Durch die Vorlesung werden theoretische Kenntnisse der Bildtechnik exemplarisch vermittelt und in Zusammenhang mit den aktuellen Entwicklungen gebracht.
> In einem in die LV integrierten begleitenden Praktikum entwickeln die Studierenden eigenständig algorithmische Lösungskonzepte und setzen diese in Matlab-Programme um.
>
> Wozu:
> Die Studierenden können akuelle Verfahren zur digitalen Bildtechnik entwickeln und in Hard- und Software implementieren. Sie können bildtechnische Verfahren analysieren, beurteilen und umsetzen sowie fachliche Führungs- und Projektverantwortung übernehmen.

Module Contents

Lecture / Exercises

Color Imaging
Color capturing with electronic sensors
Color detectors
Demosaicking
Optical antialiasing filters
Color management for DSCs
ICC profiles computing with least squares fit
Testing color accuracy
Color appearance models
Multispectral Imaging
Spectral sensitivities estimation by means of a general method to stabilize an instable set of linear equations
Statistics of natural spectra (Principal Components Analysis)
Spectral stimulus estimation

HDR Imaging
HDR capturing technology
Contrast management
photo receptor model
unsharp masking
retinex algorithm
Automatic control

Imaging Methods
Automatic white balancing
Grey world approach
Color-by-Correlation
Dichromatic reflection model
MTF management
MTF measurement
filter design for MTF optimization and sharpening
Adaptive sharpening
Denoising
Modelling of sensor noise
Locally adaptive smoothing filter
Wiener filtering
Bilateral filtering
Non-Local-Means filtering
Defect pixel / cluster correction

Describe the function and effects of different imaging methods

Lab

analyse optical and electronic imaging characteristics

recognize and assess imaging defects

realize imaging methods by software programmin according to a given specification or scientific paper

measure optical and electronic imaging characteristics or defects

implement new imaging methods according to a given specification or scientific paper

optimize imaging methods by basic mathematical optimization methods

compare image quality of different imaging methods

document results

Teaching and Learning Methods
- Lecture / Exercises
- Lab

Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	none
Mandatory Prerequisites	▪ Lab requires attendance in the amount of: 10 Termine ▪ Participation in final examination only after successful participation in Lab
Capacity-limited admission	no
Recommended Literature	▪ R.W.G. Hunt, The Reproduction of Color ▪ M. Fairchild, Color Appearance Models, Wiley, 2nd ed. ▪ G. C. Holst, T. S. Lomheim, CMOS/CCD Sensors and Camera Systems, SPIE ▪ J. Nakamura, Image Sensors and Signal Processing for Digital Still Cameras, Taylor & Francis ▪ Reinhard/Ward/Pattanaik/Debevec, High Dynamic Range Imaging, Elsevier 2010 ▪ R. Gonzales/R. Woods/Eddins, Digital Image Processing Using Matlab, Prentice Hall, 2004 ▪ W. Pratt, Digital Image Processing, Wiley, 4th ed., 2007 ▪ A. Jain, Fundamentals of Digital Image Processing, Prentice Hall, 1988
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ DBT in Master Communication Systems and Networks PO4 ▪ DBT in Master Medientechnologie PO3 ▪ DBT in Master Medientechnologie PO4
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.11 DLO - Deep Learning und Objekterkennung

Module ID	DLO
Module Name	Deep Learning und Objekterkennung
Type of Module	Elective Modules
Recognized Course	DLO - image processing master
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Jan Salmen
Lecturer(s)	Prof. Dr. Jan Salmen (Professor Fakultät IME)

Learning Outcome(s)

> Die Teilnehmer*innen können selbständig entscheiden, in welchen Situationen sich der Einsatz von Verfahren aus dem Bereich Deep Learning anbietet. Sie können eine entsprechende Lösung entwerfen, iterativ verbessern und praktisch umsetzen. Mögliche Probleme auf dem Weg dahin (z.B. beim Erstellen eines Datensatzes oder beim Training) können sie qualifiziert analysieren und passende Ideen zur Bewältigung entwickeln. Da sie einen guten Überblick über die langjährigen Entwicklungen in Forschung und Technik haben, können sie qualifiziert auf aktuelle Herausforderungen und offene Fragen im Zusammenhang mit Deep Learning schauen. Die Studierenden werden so in die Lage versetzt, sich sowohl im weiteren Studienverlauf als auch im Berufsleben kompetent mit Ansätzen zu beschäftigen, die auf Deep Learning beruhen.

Module Contents

Lecture

> Deep learning algorithms and their application for object recognition in images.

Lab

> training of a neural network
>
> evaluation of the performance of a neural network

Teaching and Learning Methods	▪ Lecture ▪ Lab
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	34 Hours ≙ 3 SWS
Self-Study	116 Hours
Recommended Prerequisites	The students should have some basic knowledge about image processing and pattern recognition
Mandatory Prerequisites	Lab requires attendance in the amount of: 4 Termine
Capacity-limited admission	no

Recommended Literature	▪ I. Goodfellow, Y. Bengio und A. Courville. Deep Learning. MIT Press, 2016 ▪ C. C. Aggarwal. Neural Networks and Deep Learning: A Textbook. Springer, 2018 ▪ C. Bishop und H. Bishop. Deep Learning: Foundations and Concepts. Springer, 2024 ▪ D. V. Godoy. Deep Learning with PyTorch Step-by-Step: A Beginner’s Guide. Fundamentals. 2022 ▪ D. V. Godoy. Deep Learning with PyTorch Step-by-Step: A Beginner’s Guide. Computer Vision. 2022
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ DLO in Master Communication Systems and Networks PO4 ▪ DLO in Master Elektrotechnik PO3 ▪ DLO in Master Elektrotechnik und Informationstechnik PO1 ▪ DLO in Master Medientechnologie PO3 ▪ DLO in Master Medientechnologie PO4 ▪ DLO in Master Technische Informatik PO3 ▪ DLO in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.12 DMC - Digital Motion Control

Module ID	DMC
Module Name	Digital Motion Control
Type of Module	Elective Modules
Recognized Course	DMC - Digital Motion Control
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Jens Onno Krah
Lecturer(s)	Prof. Dr. Jens Onno Krah (Professor Fakultät IME)

Learning Outcome(s)

Servomotoren kennenlernen und betreiben
Servoumrichter kennenlernen und verwenden
Digitale Regelalgorithmen nutzen
Prozessidentifikation und Parameterestimation
Auslegung von Antriebssystemen

Module Contents

Lecture / Exercises

Structure of servo motors
Structure of servo inverters
Digital control algorithms
Process identification
Design of drive systems

Lab

Direct Digital Control
Quasi-continuous control
Predictor / Observer
Parameterization of a control system
Evaluation of Bode diagrams
Demonstrate action competence
Commissioning of a servocontroller
Minimization of following errors

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Lab
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	RT, DSS

Mandatory Prerequisites	Lab requires attendance in the amount of: 3 Termine
Capacity-limited admission	no
Recommended Literature	▪ Krah, Jens Onno, Vorlesungsskript MC ▪ Krah, Jens Onno: Vorlesungsskript RT (Download) ▪ Handbuch ServoStar 300: www.danahermotion.net ▪ Schultz, G.: Regelungstechnik, Oldenbourg Verlag, München-Wien ▪ Lutz, Wendt: Taschenbuch der Regelungstechnik, Verlag Harri Deutsch
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ DMC in Master Communication Systems and Networks PO4 ▪ DMC in Master Elektrotechnik PO3 ▪ DMC in Master Elektrotechnik und Informationstechnik PO1 ▪ DMC in Master Technische Informatik PO3 ▪ DMC in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.13 DSP - Digital Signal Processing

Module ID	DSP
Module Name	Digital Signal Processing
Type of Module	Elective Modules
Recognized Course	DSP - Digital Signal Processing
ECTS credits	5
Language	englisch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Harald Elders-Boll
Lecturer(s)	Prof. Dr. Harald Elders-Boll (Professor Fakultät IME)

Learning Outcome(s)

> Design, analyse and implement DSP systems in soft and hardware considering computational complexity and hardware resource limitation, by a thorough understanding of the theoretical concepts, especially frequency domain analysis, and practical implementation of DSP systems in software using Python and on microprocessors, to be able to design, select, use and apply actual and future DSP systems for various signal processing application in commercial products.

Module Contents

Lecture / Exercises

Signals, Systems and Digital Signal Processing
Basic Elements of DSP Systems
Classification of Signals
Continuous-Time and Discrete-Time Signals
Deterministic and Random Signals
Even and Odd Signals
Periodic and Aperiodic Signals
Energy and Power of Signals
Some Fundamental Signals

Discrete-Time Linear Time-Invariant Systems
Difference Equations
Discrete-Time Convolution
Unit-Pulse and Impulse Response
Basic Systems Properties: Causality, Stability, Memory

Ideal Sampling and Reconstruction
Ideal Sampling and the Sampling Theorem
Aliasing

Fourier-Transform of Discrete-Time Signals
Eigenfunctions of Discrete-Time LTI Systems
Frequency response of Discrete-Time LTI Systems
The Fourier-Transform of Discrete-Time Signals
Ideal Continuous-Time Filters

Discrete Fourier-Transform
Sampling the DTFT
The DFT and the Inverse DFT
The Fast Fourier Transform
Radix-2 FFT Algorithms
Linear Convolution Using the FFT
Overlap-And-Add

Random Signals
Review of Probablity and Random Variables
Ensemble Averages
Correlation Functions
Stationary and Ergodic Processes
Power Spectral Density
Transmission of Random Signals over LTI Systems

Advanced Sampling Techniques
Quantization and Encoding
Sampling of Bandpass Signals
Sampling of Random Signals
Sample Rate Conversion
Sample Rate Reduction by an Integer Factor
Sample Rate Increase by an Integer Factor
Sample Rate Conversion by a Rational Factor
Oversampling and Noise Shaping

Students understand the fundamentals of discrete-time signals and systems

Students can analyse the frequency content of a given signal using the appropriate Fourier-Transform and methods for spectrum estimation

Analysis of discrete-time LTI Systems
Students can calculate the output signal via convolution
Students can determine the frequency response of a given system
Students can characterize a given system in the frequency domain and in the z-domain

Implementation of discrete-time LTI systems
Students can implement the convolution sum in software
Students can implement different structures for IIR systems in software
Sudents can use the FFT to implement an FIR system

Lab

Review of Probablity and Random Variables
Moments, Averages and Distribution Functions

Random Signals
Ensemble Averages
Correlation Functions
Stationary and Ergodic Processes
Power Spectral Density
Transmission of Random Signals over LTI Systems

Combatting noise
Remove or suppress high-frequency noise from low-pass signals

Abilty to trade-off different methods for digital coding of speech and audio signals

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Lab
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	No formal requirements, but students will be expected to be familiar with: Basic Knowledge of Signals and Systems: Continuous-Time LTI-Systems and Convolution, Fourier-Transform Basic Knowledge of Probability and Random Variables
Mandatory Prerequisites	▪ Lab requires attendance in the amount of: 8 Termine ▪ Participation in final examination only after successful participation in Lab
Capacity-limited admission	no
Recommended Literature	▪ John G. Proakis and Dimitris K. Manolakis. Digital Signal Processing (4th Edition). Prentice Hall, 2006. ▪ Alan V. Oppenheim, Ronald W. Schafer. Discrete-Time Signal Processing (3rd Edition). Prentice Hall, 2007. ▪ Vinay Ingle and John Proakis. Digital Signal Processing using MATLAB. Cengage Learning Engineering, 2011.
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2 ▪ PFM - Profile Module
Included in Specialization	CS - Communication Systems
Use of the Module in Other Study Programs	▪ DSP in Master Communication Systems and Networks PO4 ▪ DSP in Master Elektrotechnik und Informationstechnik PO1 ▪ DSP in Master Technische Informatik PO3 ▪ DSP in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.14 EBA - Elektrische Bahnen

Module ID	EBA
Module Name	Elektrische Bahnen
Type of Module	Elective Modules
Recognized Course	EBA - Electric Railways
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Wolfgang Evers
Lecturer(s)	Prof. Dr. Wolfgang Evers (Professor Fakultät IME)

Learning Outcome(s)

> Die Studierenden können Systeme der elektrischen Schienenbahnen analysieren und einen interdisziplinären Kontext herstellen, indem sie die für die jeweilige Problemstellung geeigneten Zusammenhänge kombinieren und so zu Lösungen kommen, um später Elektroausrüstungen für Schienenfahrzeuge und Schieneninfrastruktur zu entwickeln, zu projektieren oder zu betreiben.

Module Contents

Lecture / Exercises

> - Railway vehicles with commutator motors
> * DC railways
> * Alternating current railways
> - Railway vehicles with three-phase motors
> * Asynchronous machine
> * Power converter for the asynchronous machine
> * Synchronous machine
> - Linear drives
> - Magnetic levitation systems
> * Static-catching levitation
> * Dynamic-repulsive hovering
> * Static-repulsive hovering
> - Executed and projected magnetic levitation trains
> * Transrapid
> * MagLev system

> - Discuss and evaluate the advantages and disadvantages of different systems (power systems, wheel / rail vs. magnetic levitation)
> - Classification of electrotechnical solutions in interdisciplinary concepts

Lab

> Working out various aspects of railway operation using computer simulations

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Lab
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS

Self-Study	105 Hours
Recommended Prerequisites	Fundamentals of electrical engineering, electronics and mechanics Basic understanding of electrical machines
Mandatory Prerequisites	▪ Lab requires attendance in the amount of: 2 Termine ▪ Participation in final examination only after successful participation in Lab
Capacity-limited admission	yes, according to approved request
Recommended Literature	▪ Zarko Filipovic, Elektrische Bahnen Springer Verlag, 1989, ISBN 3-540-55093-3
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ EBA in Master Communication Systems and Networks PO4 ▪ EBA in Master Elektrotechnik PO3 ▪ EBA in Master Elektrotechnik und Informationstechnik PO1
Specifics and Notes	
Last Update	22.10.2025, 11:22:18

6.15 EMM - Energiemanagement in Energieverbundsystemen

Module ID	EMM
Module Name	Energiemanagement in Energieverbundsystemen
Type of Module	Elective Modules
Recognized Course	EMM - Energy Management in Interconnected Systems
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Ingo Stadler
Lecturer(s)	Prof. Dr. Ingo Stadler (Professor Fakultät IME)

Learning Outcome(s)

Die Studierenden analysieren die Mechanismen und Voraussetzungen zur Garantie der Stabilität von elektrischen Verbundsystemen, indem sie die Frequenz- und Spannungsstabilität beeinflussenden Kriterien kennen, um später neue Maßnahmen in einem geänderten, auf erneuerbaren Energien basierenden Energiesystem zur Gewährleistung der Stabilität entwickeln zu können.

Die Studierenden analysieren die Regelmechanismen heutiger Verbundsysteme, indem Sie die Begrifflichkeiten, die Wirkungsweise und die Organisation verschiedener Stufen der Regelleistung und Regelenergie verstehen, um zukünftige Maßnahmen und Alternativen zu deren Bereitstellung einschätzen und selbst entwickeln können.

Die Studierenden kennen Möglichkeiten zur Sektorenkopplung und können deren Einsatz zum Demand Response bewertem, indem Sie Differentialgleichungen zur Lösung von Bilanzproblemen erstellen und lösen können, numerischer Verfahren zur Lösung nicht stationärer Veränderungen in Speichersystemen erstellen und anwenden können, um damit Lösungen in verschiedenen Zeit- und Leistungsbereichen des Demand Response zu beurteilen.

Die Studierenden kennen und sind in der Lage, Technologien der Energiespeicherung in verschiedensten Zeit-, Energie- und Leistungsbereichen zu beurteilen, indem sie die relevanten Charakteristiken und Ökonomien kennen, um deren Einsatz für unterschiedliche Anwendungen beurteilen zu können.

Die Studierenden sind in der Lage, die verschiedensten Möglichkeiten zur Herstellung der Blindleistungsbilanz in Verbundsystemen benennen und zu anlysieren, indem sie die Leitungsgleichungen zur Netzanalyse anwenden, um mit verschiedenen Maßnahmen die Spannungsqualität gewährleisten zu können.

Module Contents

Lecture

The students analyse the mechanisms and prerequisites for guaranteeing the stability of interconnected electrical systems by knowing the criteria influencing frequency and voltage stability in order to later be able to develop new measures in a changed energy system based on renewable energies to guarantee stability.
The students analyse the control mechanisms of today's interconnected systems by understanding the terminology, the mode of operation and the organisation of different levels of control power and control energy in order to be able to assess future measures and alternatives for their provision and develop them themselves.
The students know possibilities for sector coupling and can evaluate their use for demand response by creating and solving differential equations for solving balance problems, creating and applying numerical methods for solving non-stationary changes in storage systems in order to evaluate solutions in different time and power ranges of demand response.
Students will know and be able to evaluate energy storage technologies in a wide range of time, energy and power domains by knowing the relevant characteristics and economics to assess their use for different applications.
The students are able to name and analyse the various possibilities for establishing the reactive power balance in interconnected systems by applying the line equations for network analysis in order to be able to guarantee the voltage quality with various measures.

Project

Changing current projects are worked on.

Teaching and Learning Methods	▪ Lecture ▪ Project
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	34 Hours ≙ 3 SWS
Self-Study	116 Hours
Recommended Prerequisites	None
Mandatory Prerequisites	Project requires attendance in the amount of: 3 Termine
Capacity-limited admission	no
Recommended Literature	
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ EMM in Master Communication Systems and Networks PO4 ▪ EMM in Master Elektrotechnik PO3 ▪ EMM in Master Elektrotechnik und Informationstechnik PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.16 HIM - Advanced Mathematics

Module ID	HIM
Module Name	Advanced Mathematics
Type of Module	Mandatory Module
Recognized Course	HIM - Advanced Mathematics
ECTS credits	5
Language	deutsch und englisch
Duration of Module	1 Semester
Recommended Semester	1
Frequency of Course	every term
Module Coordinator	Prof. Dr. Heiko Knospe
Lecturer(s)	▪ Prof. Dr. Heiko Knospe (Professor Fakultät IME) ▪ Prof. Dr. Hubert Randerath (Professor Fakultät IME) ▪ Prof. Dr. Beate Rhein (Professorin Fakultät IME)

Learning Outcome(s)

> Was: Das Modul vermittelt grundlegende Konzepte und Methoden der Mathematik, die in den Ingenieurwissenschaften benötigt werden (K. 8). Die Abstraktion und mathematischen Formalisierung von Problemen soll erlernt und angewendet werden (K. 2). Die Studierenden lernen die Anwendung mathematischer Methoden (K. 16). Es soll die Anwendung statistischer Verfahren und die Begründung wissenschaftlicher Aussagen erlernt werden (K. 17).
> Womit: Der Dozent/die Dozentin vermittelt Wissen und Basisfertigkeiten in der Vorlesung. In der Übung bearbeiten die Studierenden unter Anleitung Aufgaben. Die Übung wird durch Hausaufgaben und Online-Aufgaben (E-Learning) ergänzt.
> Wozu: Fortgeschrittene Mathematik-Kenntnisse (beispielweise in Vetoranalysis, Statistik und Optimierung) werden in mehreren Moduln des Studiengangs benötigt. Mathematische Methoden sind essentiell für Ingenieure, die wissenschaftlch arbeiten und wissenschaftliche Erkenntnisse anwenden und erweitern (HF2).

Module Contents

Lecture / Exercises

A combination of:
- Vector Analysis
- Probability Theory, Statistics and Multivariate Statistics
- Stochastic processes
- Optimization

Vector Analysis
- Vector Spaces
- Scalar and Vector Functions
- Differential Operators
- Line Integrals
- Double Integrals
- Triple Integrals
- Change of Variables
- Surface Integrals
- Divergence Theorem
- Theorem of Stokes
- Maxwell Equations

Probability and Statistics
- Descriptive Statistics
- Two-dimensional Data
- Simple Linear Regression
- Probability Spaces
- Random Variables
- Expectation, Variance, Moments
- Jointly Distributed Random Variables
- Independent Random Variables
- Covariance
- Binomial Random Variable
- Poisson Random Variable
- Uniform Random Variable
- Normal Random Variable
- Chi-Square Distribution
- t-Distribution
- Central Limit Theorem
- Distributions of Sampling Statistics
- Confidence Intervals
- Hypothesis Testing
- t-Test, f-Test, Chi-Square Test
- Overview of various Tests

Multivariate Statistics
- Analysis of multidimensional data
- Multivariate Random Variables
- Matrix decompositions, Singular Value Decomposition (SVD)
- Factor analysis, Principal Component Analysis (PCA)
- Multiple Linear Regression

Stochastic Processes
- Discrete and continuous time processes
- Random walk
- Markov chain
- Poisson process
- Queuing theory

Optimization
- Linear Programming
- Unconstrained Optimization: Gradient method, Newton's method, Trust Region method
- Constrained Optimization: Karush–Kuhn–Tucker (KKT) conditions, Lagrange multipliers, Penalty and Barrier functions
- Special optimization problems: Mixed Integer Nonlinear Programming, Nonlinear Stochastic Optimization

-

Teaching and Learning Methods	Lecture / Exercises
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	34 Hours ≙ 3 SWS
Self-Study	116 Hours
Recommended Prerequisites	Differential and integral calculus and linear algebra (Bachelor-level mathematics)
Mandatory Prerequisites	
Capacity-limited admission	no
Recommended Literature	▪ K. Burg, H. Haf, F. Wille, A. Meister, Vektoranalysis - Höhere Mathematik für Ingenieure, Naturwissenschaftler und Mathematiker, Springer Vieweg ▪ E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons ▪ L. Papula, Mathematik für Ingenieure und Naturwissenschaftler Band 3, Springer Vieweg ▪ R. E. Walpole, R. H. Myers, S. L. Myers, K. Ye, Probability & Statistics for Engineers & Scientists, Prentice Hall ▪ S. M. Ross, Probability and Statistics for Engineers and Scientists, Elsevier ▪ S. M. Ross, Stochastic Processes, John Wiley & Sons ▪ U. Krengel, Einführung in die Wahrscheinlichkeitstheorie und Statistik ▪ A. Koop, H. Moock, Lineare Optimierung, Springer ▪ R. Reinhardt, A. Hoffmann, T. Gerlach, Nichtlineare Optimierung, Springer ▪ M. Ulbrich, S. Ulbrich, Nichtlineare Optimierung, Birkhäuser
Included in Elective Catalog	
Included in Specialization	
Use of the Module in Other Study Programs	▪ HIM in Master Communication Systems and Networks PO4 ▪ HIM in Master Elektrotechnik PO3 ▪ HIM in Master Elektrotechnik und Informationstechnik PO1 ▪ HIM in Master Technische Informatik PO3 ▪ HIM in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.17 HSUT - Hochspannungsübertragungstechnik

Module ID	HSUT
Module Name	Hochspannungsübertragungstechnik
Type of Module	Elective Modules
Recognized Course	HSUT - High Voltage Transmission Technology
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Christof Humpert
Lecturer(s)	Prof. Dr. Christof Humpert (Professor Fakultät IME)

Learning Outcome(s)

> Die Studierenden können Systeme und Betriebsmittel der Hochspannungsübertragungstechnik hinsichtlich technischer und betriebswirtschaftlicher Kriterien analysieren und auswählen, indem sie
> - Anforderungen an Übertragungssysteme erkennen,
> - Spannungsbelastungen im Nenn- und Fehlerfall bestimmen und Maßnahmen zur Reduktion der Belastungen auslegen,
> - Vor- und Nachteile aktueller und zukünftiger Technologien analysieren und
> - vereinfachte Wirtschaftlichkeitsberechnungen durchführen,
> um später fundierte Entscheidungen hinsichtlich des optimalen Aus- und Umbaus der elektrischen Netze unter gesellschaftlichen und politischen Randbedingungen treffen zu können.

Module Contents

Lecture / Exercises

Overvoltages and insulation coordination
- Generation and categories of overvoltages
- Propagation of overvoltages
- Traveling waves
- Reflections
- Limitation of overvoltages
- Types of surge arresters
- Properties, structure and selection

Systems of high voltage transmission
- High-voltage AC transmission (HVAC)
- Optimal transmission voltage
- Structure and different types of switchgears, their properties and applications
- High-voltage DC transmission (HVDC)
- Advantages and disadvantages in comparison to HVAC
- Structure and operation of converter stations
- Cost comparison to HVAC systems
- HVDC grids

Equipment of high voltage transmission
- Circuit breakers
- Principle of operation
- Different Types and their applications
- Circuit breakers for HVDC
- Superconducting equipment (cables, current limiters)
- Principle of operation and applications
- Cooling technology
- Losses and costs

Determine the stresses of transmission systems
- Calculate operating voltages and overvoltages for a given voltage level
- Plan limitation of overvoltages
- Analyze and calculate traveling wave processes (refraction, reflection)
- Derive current carrying capacity and maximum losses

Determine business aspects
- Carry out investment cost comparison
- Perform operating cost comparison

Project

Deepening a specific problem in electrical engineering using a calculation example

Solve project task in the team
Compile the basics of a calculation software
Perform numerical calculations
Compare numerical results with analytical
Discuss results related to practical application
Summarize results in a report

Lab

Generation and measurement of AC, DC and impulse voltages
Propagation and limitation of overvoltages

Plan high voltage tests
Dimension high voltage test circuits

> Determine test criteria for components of high voltage technology
> Summarize results in a report

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Project ▪ Lab
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	57 Hours ≙ 5 SWS
Self-Study	93 Hours
Recommended Prerequisites	Basics of electrical engineering and electronics Basic understanding of electric fields in dielectrics
Mandatory Prerequisites	▪ Lab requires attendance in the amount of: 3 Termine ▪ Participation in final examination only after successful participation in Lab
Capacity-limited admission	no
Recommended Literature	▪ Küchler, Andreas: Hochspannungstechnik: Grundlagen – Technologie – Anwendung (Springer) ▪ Heuck, Klaus; Dettmann, Klaus-Dieter; Schulz, Detlef: Elektrische Energieversorgung (Springer)
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ HSUT in Master Communication Systems and Networks PO4 ▪ HSUT in Master Elektrotechnik PO3 ▪ HSUT in Master Elektrotechnik und Informationstechnik PO1
Permanent Links to Organization	ILU course for High Voltage Transmission Technology
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.18 IBD - InnoBioDiv

Module ID	IBD
Module Name	InnoBioDiv
Type of Module	Elective Modules
Recognized Course	IBD - InnoBioDiv student projects
ECTS credits	5
Language	englisch
Duration of Module	0.5 Semester
Recommended Semester	1-2
Frequency of Course	every term
Module Coordinator	Prof. Dr. Uwe Dettmar
Lecturer(s)	Prof. Dr. Uwe Dettmar (Professor Fakultät IME)

Learning Outcome(s)

> Die Studierenden können in einer Forschungsgruppe ein Experiment teamorientiert planen, durchführen, auswerten und dokumentieren,
> indem sie auf biologisches und technisches Basiswissen und auf die zur Verfügung gestellten Ressourcen (ein IoT basiertes Mess- und Steuersystem inklusive FarmBot, Sensorik und Aktorik, Materialien und Geräte im Gewächshaus des Instituts für Pflanzenwissenschaften, Checklisten) sowie weitere frei verfügbare Informationsquellen zugreifen,
> um die Auswirkungen des Klimawandels auf die Wachstumsleistung von Pflanzen und die Biodiversität im Boden erfahrbar zu machen und dadurch Erkenntnisse zu generieren, die für die Gesellschaft im Rahmen des Klimawandels von Relevanz sind.

Module Contents

Seminar

> Development of project ideas, discussion and further development of the projects

Project

> The students acquire...
> - the ability to develop and implement concepts for the adaptation of plants to climate change.
> - the ability to plan, conduct and analyze experiments in the fields of plant physiology, soil biology and technology.
> - the ability to statistically evaluate and present experimental data.
> - the ability to present and communicate scientific results.
> - the ability to collaborate interdisciplinary and interculturally and to exchange ideas with students from differentMINT research areas.
> - Experience in planning and implementing projects and in teamwork

> At the end, students will have
> - a deep understanding of the interactions between climate parameters, plant growth and soil biodiversity.
> - basic knowledge of modern technologies such as robotics, sensor technology and the Internet of Things in the context of plant research.
> - an awareness of the importance of sustainability, resource conservation and security of supply in the context of population growth and climate change.

Teaching and Learning Methods	▪ Seminar ▪ Project
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	23 Hours ≙ 2 SWS

Self-Study	127 Hours
Recommended Prerequisites	- fluent English since working intercultural and interdisciplinary teams. - basic knowledge in IoT and robotics desireable - ability to work in a team - basic knowledge in plant bilology are not mandatory
Mandatory Prerequisites	▪ Seminar requires attendance in the amount of: 8 Stunden ▪ Project requires attendance in the amount of: 5 meetings for project discussions
Capacity-limited admission	no
Recommended Literature	▪ https://farm.bot/ ▪ Arif, Tarik M.: Deep Learning on Embedded Systems: A Hands-On Approach Using Jetson Nano and Raspberry Pi, Wiley, 2025, ISBN:978-1-394-26927-3 ▪ Agrawal, D. P. (2017). Embedded Sensor Systems. Springer. ▪ Marwedel, Peter: Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems, and the Internet of Things, Springer, 2021, ISBN 978-3-030-60910-8 ▪ L. Urry, S. Wassermann: Campbell Biology AP Edition (12th Edition), Pearsson, ISBN-13: 978-0-13-648687-9 ▪ Taiz, L., Møller, I. M., Murphy, A., & Zeiger, E. (2022). Plant Physiology and Development. Oxford University Press.
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ IBD in Master Communication Systems and Networks PO4 ▪ IBD in Master Elektrotechnik und Informationstechnik PO1 ▪ IBD in Master Medientechnologie PO4 ▪ IBD in Master Technische Informatik PO3 ▪ IBD in Master Informatik und Systems-Engineering PO1
Permanent Links to Organization	Course description in the learning platform
Specifics and Notes	Block course from the beginning of October to mid-November (7 weeks), optional preparation time to build up basic knowledge in the last week of September
Last Update	19.7.2025, 14:32:16

6.19 IIS - Intelligent Information Systems

Module ID	IIS
Module Name	Intelligent Information Systems
Type of Module	Elective Modules
Recognized Course	IIS - Intelligent Information Systems
ECTS credits	5
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Andreas Behrend
Lecturer(s)	Prof. Dr. Andreas Behrend (Professor Fakultät IME)

Learning Outcome(s)

Die Studierenden kennen die verschiedenen Möglichkeiten zur Darstellung von Wissen und können die Vor – und Nachteile einer Darstellungsform bewerten.
Die Studierenden erarbeiten sich grundlegende Kenntnisse zur Theorie und Anwendung von deklarativen Programmiersprachen bzw. Regelsystemen.
Die Studierenden kennen gängige Typen von Optimierungs- bzw. Suchproblemen und können geeignete deklarative Lösungsansätze identifizieren.
Die Studierenden kennen die wichtigsten Inferenzmethoden und können diese einordnen bzw. bewerten.
Die Studierenden kennen die Resolutionsmethode und das Verfahren der Unifikation und können diese für eine Problemstellung anwenden.
Die Studierenden kennen die wichtigsten Formen der Operationalisierung deklarativer Ausdrücke und können diese bzgl. ihrer Effizienz bei einem Lösungsansatz bewerten.
Die Studierenden können für reale Problemstellungen eine geeignete Wissensrepräsentation wählen und eine Lösung mit einem deklarativen Programm erarbeiten.
Die Studierenden können aktuelle deklarative Anfragesprachen klassifizieren und hinsichtlich ihrer Ausdrucksmächtigkeit bewerten.

Die Studierenden können mit gängigen deklarativen Programmiersprachen umgehen.
Die Studierenden können Aufgaben in einem kleinen Team lösen.
Die Studierenden können Programmcode verstehen und um Funktionalität erweitern. Sie können das Verhalten einer programmierten Lösung bewerten und durch geeignete Modifikationen verbessern.
Die Studierenden können internationale wissenschaftliche Literatur analysieren, einordnen, in ihren Kontext stellen und präsentieren.

Module Contents

Lecture / Exercises

Foundations of Knowledge Representation
- First-order logic
- relational, functional, tree-based, graph-oriented fact representation
(semantic networks, ontologies)
- rule-based systems

Automatic reasoning and inference methods
- resolution principle (incl. unification)
- forward and backward chaining
- fixpoint semantics

Declarative Programming languages
- Functional programming
- relational (logical) programming , e.g., Prolog, Datalog, SQL and SPARQL

Outlock on current research issues, e.g., query languages, parallel algorithms, distributed systems, combinatorial optimization and language processing.

Students have acquired basic knowledge about methods for representing knowledge, automatic reasoning as well as declarative programming languages. They understand the various ways of operationalizing declarative expressions and are able to realize suitable programming solutions for given problems.

Lab

Representing knowledge by sets of tuples, relations, semantic networks as well as logic-based
systems
Implementing calculation problems with a functional programming language (e.g. Haskell) using expressions, algebraic data types, infinite data structures and higher-order functions
Solving search problems with a logical programming language and recursive expressions
Formulating relational queries over knowledge bases (e.g. using SPQAQL or Datalog)

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Lab
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	programming skills, knowledge about data structures and algorithms
Mandatory Prerequisites	
Capacity-limited admission	no
Recommended Literature	▪ G. Hutton: Programming in Haskell, 2nd Ed., Cambridge University Press, 2016 ▪ L. Sterling, E. Shapiro: The Art of Prolog, 2nd Ed., MIT Press, 1994 ▪ Uwe Schöning. Logik für Informatiker. 5. Auflage, Spektrum Akademischer Verlag, 2000 ▪ Pascal Hitzler, Markus Krötzsch, Sebastian Rudolph. Foundations of Semantic Web Technologies. CRC Press 2009. ▪ S.J. Russell, P. Norvig: Artificial Intelligence. A Modern Approach, 2. Aufl. Prentice Hall, 2003

Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ IIS in Master Communication Systems and Networks PO4 ▪ IIS in Master Technische Informatik PO3 ▪ IIS in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.20 ITF - IT-Forensik

Module ID	ITF
Module Name	IT-Forensik
Type of Module	Elective Modules
Recognized Course	ITF - IT forensics
ECTS credits	5
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Studiengangsleiter(in) Master Technische Informatik (Informatik und Systems-Engineering)
Lecturer(s)	Jürgen Bornemann (Lehrbeauftragter)

Learning Outcome(s)

- **WAS** Studierende spüren digitale Beweise auf und stellen Sie zwecks Verwertbarkeit für weiterführende Analysen sicher,
- **WOMIT** indem sie anhand fallbezogener Aufgabenstellungen und mittels forensischer IT-Tools Schwachstellen entdecken und Beweise in Dateisystemen und IT-Infrastrukturen sichern,
- **WOZU** um im Berufsleben Gefahren vermeiden, erkennen und abwehren können und ggf. gutachterlich tätig zu werden.

Module Contents

Lecture / Exercises

Basic concepts of cyber security and digital forensics

Typical vulnerabilities, threats and risks

Dangers with mobile systems, home office, WLANs

Basics and working methods of IT forensics

Forensic documentation creation

Common tools for forensic investigations

Recognize and secure digital evidence

Open source forensics

File system forensics

Forensic analysis of mobile systems

Vulnerabilities, threats, attacks on network structures

KALI Linux - Operating System for Vulnerability and Pentesting

Project

Students can work on case-related forensic tasks and incidents independently or in working groups using the knowledge they have acquired. They show how to secure, analyze and document digital evidence.

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Project
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS

Self-Study	105 Hours
Recommended Prerequisites	
Mandatory Prerequisites	
Capacity-limited admission	no
Recommended Literature	
Included in Elective Catalog	
Included in Specialization	
Use of the Module in Other Study Programs	▪ ITF in Master Communication Systems and Networks PO4 ▪ ITF in Master Elektrotechnik PO3 ▪ ITF in Master Elektrotechnik und Informationstechnik PO1 ▪ ITF in Master Medientechnologie PO3 ▪ ITF in Master Medientechnologie PO4 ▪ ITF in Master Technische Informatik PO3 ▪ ITF in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.21 KOGA - Kombinatorische Optimierung und Graphenalgorithmen

Module ID	KOGA
Module Name	Kombinatorische Optimierung und Graphenalgorithmen
Type of Module	Elective Modules
Recognized Course	KOGA - Combinatorial Optimization and Graph Algorithms
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Hubert Randerath
Lecturer(s)	Prof. Dr. Hubert Randerath (Professor Fakultät IME)

Learning Outcome(s)

> Die Studierenden sind in der Lage Verfahren und Konzepte der Graphentheorie und der Kombinatorischen Optimierung zur Beschreibung und algorithmischen Lösung von Problemstellungen der Informatik, der Technik und des täglichen Lebens anzuwenden.
>
> Sie haben die Fertigkeit Verfahren und Konzepte der Graphentheorie und der Kombinatorischen Optimierung zur Beschreibung und algorithmischen Lösung von Problemstellungen der Informatik, der Technik und des täglichen Lebens anzupassen.
>
> Sie können algorithmische Denk- und Arbeitweisen wie Komplexität von Problemklassen, Effizienz von Algorithmen und Approximation, die sie induktiv an Optimierungsaufgaben in Netzwerken und gewichteten Graphen erlernt haben, anwenden.

Module Contents

Lecture / Exercises

> - Basics of Graph Theory und Combinatorial Optimization
> - Minimal Spanning Trees: algorithms of Kruskal, Prim und Tarjan, Greedy algorithms, matroids, Steiner trees, network design
> - Linear Programs: structure, modelling, normalization, Simplex algorithm, Theory of Duality
> - Weighted Matchings and the Routhe Inspection Problem: Weighted Matchings in Bipartite Graphs and non-bipartite Graphs, algorithms of Floyd-Warshall and Fleury
> - Network Flows: Network Theory Basics, Dinic's algorithms, cost-optimial flows
> - selected discreet and combinatorial optimization problems: Travelling Salesman, Channel Assignment Problem, scheduling problems, routing problems

Exercises / Lab

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Exercises / Lab
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	57 Hours ≙ 5 SWS
Self-Study	93 Hours
Recommended Prerequisites	Basic knowledge in graph theory Basic knowledge in algorithmics

Mandatory Prerequisites	▪ Lecture / Exercises requires attendance in the amount of: 1 Vortragstermin ▪ Exercises / Lab requires attendance in the amount of: 1 Termin
Capacity-limited admission	no
Recommended Literature	▪ Mathematik zum Studienbeginn, Arnfried Kemnitz, Springer Spektrum Verlag ▪ Algorithmische Graphentheorie, Volker Turau und Christian Weyer, De Gruyter Verlag ▪ Graphentheoretische Konzepte und Algorithmen, Sven Krumke und Harald Noltemeier, Springer Vieweg Verlag ▪ Einführung in die angewandte Wirtschaftsmathematik, Jürgen Tietze, Springer Spektrum Verlag ▪ Graph Algorithms - Practical Examples in Apache Spark & Neo4j, Mark Needham and Amy Hodler, O'Reilly Verlag
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ KOGA in Master Communication Systems and Networks PO4 ▪ KOGA in Master Technische Informatik PO3 ▪ KOGA in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.22 KOLL (MAKOLL) - Kolloquium zur Masterarbeit

Module ID	KOLL
Module Name	Kolloquium zur Masterarbeit
Type of Module	Mandatory Module
Recognized Course	MAKOLL - Colloquium
ECTS credits	3
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	3
Frequency of Course	every term
Module Coordinator	Studiengangsleiter(in) Master Technische Informatik (Informatik und Systems-Engineering)
Lecturer(s)	verschiedene Dozenten*innen (diverse lecturers)

Learning Outcome(s)

> - Darstellung von Forschungsergebnissen in einer Präsentation in vorgegebenem engen zeitlichen Rahmen
> - Fachliche und außerfachliche Bezüge der eigenen Arbeit darstellen und begründen
> - Eigene Lösungswege und gewonnene Erkenntnisse darstellen und diskutieren

Module Contents

Colloquium

> The colloquium serves to determine whether the student is able to present the results of the Master's thesis, its technical and methodological foundations, interdisciplinary contexts and extracurricular references orally, to justify them independently and to assess their significance for practice

Teaching and Learning Methods	Colloquium
Examination Types with Weights	cf. exam regulations
Workload	90 Hours
Contact Hours	0 Hours ≙ 0 SWS
Self-Study	90 Hours
Recommended Prerequisites	
Mandatory Prerequisites	▪ Module MAA: Die Masterarbeit muss abgeschlossen sein, damit sie im Kolloquium ganzheitlich und abschließend präsentiert werden kann. ▪ See exam regulations §29, paragraph 2
Capacity-limited admission	no
Recommended Literature	
Included in Elective Catalog	
Included in Specialization	

Use of the Module in Other Study Programs	▪ KOLL in Master Communication Systems and Networks PO4 ▪ KOLL in Master Elektrotechnik PO3 ▪ KOLL in Master Elektrotechnik und Informationstechnik PO1 ▪ KOLL in Master Medientechnologie PO3 ▪ KOLL in Master Medientechnologie PO4 ▪ KOLL in Master Technische Informatik PO3 ▪ KOLL in Master Informatik und Systems-Engineering PO1
Specifics and Notes	See also examination regulations §29.
Last Update	14.11.2025, 14:33:56

6.23 KRY - Cryptography

Module ID	KRY
Module Name	Cryptography
Type of Module	Elective Modules
Recognized Course	KRY - Cryptography
ECTS credits	5
Language	englisch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Heiko Knospe
Lecturer(s)	Prof. Dr. Heiko Knospe (Professor Fakultät IME)

Learning Outcome(s)

Was: Die Studierenden lernen die mathematischen Grundlagen der Kryptographie kennen. Es werden Kenntnisse der wichtigsten kryptographischen Methoden und Algorithmen vermittelt (HF 1). Die Studierenden verstehen verschiedene Arten von SIcherheitsanforderungen und analysieren die Sicherheit von kryptographischen Verfahren.
Womit: Der Dozent/die Dozentin vermittelt Wissen und Basisfertigkeiten in der Vorlesung. In der Übung bearbeiten die Studierenden unter Anleitung Aufgaben. Im Praktikum werden konkrete Probleme und Fragestellungen der Kryptographie bearbeitet.
Wozu: Kryptographie wird eingesetzt um die grundlegenden Ziele der Informationssicherheit zu erreichen. Die Studierenden lernen die Implemenierung und Anwendung von kryptographischen Algorithmen und entwickeln Konzepte um Systeme, Netzwerke und Anwendungen gegen Angriffe zu sichern (HF 2).

Module Contents

Lecture / Exercises

* Mathematical Fundamentals
* Encryption Schemes and Definitions of Security
* Elementary Number Theory
* Algebraic Structures
* Block Ciphers
* Stream Ciphers
* Hash Functions
* Message Authentication Codes
* Public-Key Encryption and the RSA Cryptosystem
* Key Establishment
* Digital Signatures
* Elliptic Curve Cryptography
* Outlook: Post-quantum cryptography

Lab

- Solve mathematical and cryptographical problems in Python / SageMath: working with large integers and residue classes, factorization, primality and prime density, RSA key generation and encryption / decryption, Diffie-Hellman key exchange.
- Write code to encrypt and decrypt files using the AES block cipher and different operation modes. Analyze the statistical properies of AES ciphertext.
- Write code for RSA key generation, key encapsulation / decapsulation and hybrid encryption / decryption.

Teaching and Learning Methods

- Lecture / Exercises
- Lab

Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	Mathematics (Bachelor level) and programming skills.
Mandatory Prerequisites	▪ Lab requires attendance in the amount of: 3 Termine ▪ Participation in final examination only after successful participation in Lab
Capacity-limited admission	no
Recommended Literature	▪ M. Bellare, P. Rogaway, Introduction to Modern Cryptography, UCSD CSE ▪ H. Delfs, H. Knebl, Introduction to Cryptography, Springer ▪ S. Goldwasser, M. Bellare, Lecture Notes on Cryptography, MIT ▪ J. Hoffstein, J. Pipher, J.H. Silverman, An Introduction to Mathematical Cryptography, Springer ▪ J. Katz, Y. Lindell, Introduction to Modern Cryptography, CRC Press ▪ H. Knospe, A Course in Cryptography, American Mathematical Society ▪ C. Paar, J. Pelz, Understanding Cryptography. Springer ▪ N.P. Smart, Cryptography Made Simple, Springer ▪ K. H. Rosen, Discrete Mathematics and its Applications, McGraw-Hill ▪ V. Shoup, A Computational Introduction to Number Theory and Algebra, Cambridge University Press
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2 ▪ PFM - Profile Module
Included in Specialization	▪ CS - Communication Systems ▪ N_S - Networks & Security
Use of the Module in Other Study Programs	▪ KRY in Master Communication Systems and Networks PO4 ▪ KRY in Master Technische Informatik PO3 ▪ KRY in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.24 LCSS - Large and Cloud-based Software-Systems

Module ID	LCSS
Module Name	Large and Cloud-based Software-Systems
Type of Module	Elective Modules
Recognized Course	LCSS - Large and Cloud-based Software-Systems
ECTS credits	5
Language	englisch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. René Wörzberger
Lecturer(s)	Prof. Dr. René Wörzberger (Professor Fakultät IME)

Learning Outcome(s)

> Students are capable of
>
> - designing architectures for complex and mission critical enterprise software systems,
> - implementing these systems and
> - operate them in the Cloud
>
> by
>
> - knowing and trading conflicting interests and concerns of stakeholders,
> - knowing quality attributes and their trade-offs,
> - specifying architecturally significant requirements in quality attribute scenarios,
> - analysing design decisions with respect to their effects on quality attributes and stake-holder interests and concerns,
> - presenting and documenting architectures by means of suitable views, notations and tools,
> - applying methods (like RESTful API design) and tools in order to implement design deci-sions,
> - using cloud resources like virtual machines, containers and storages in order to operate a system in the cloud,
>
> in order to
>
> - be able to produce long-term usable software systems in subsequent lectures and pro-jects and
> - to be able to act as an IT architect, e.g. in an IT department of a larger enterprise.

Module Contents

Lecture / Exercises

- Formally sound handling of quality requirements for availability, performance, capacity and cost efficiency
- Advantages and disadvantages of basic system architecture styles, such as microservice architectures
- Scaling of systems and individual tiers, also with regard to possible deployment strategies such as canary or AB deployment, as well as associated load balancing strategies (e.g. consisten hashing)
- Advanced applications of virtualization, in particular container virtualization and orchestration, for example with Docker and Kubernetes
- Selection of suitable communication patterns and protocols, in particular HTTP and derivatives such as websockets, server-sent events and gRPC
- Selection of appropriate API technologies and design philosophies such as REST and GraphQL
- Use of basic security protocols such as TLS, OAuth2, JWT and OpenID Connect
- Asynchronous, event-driven communication via messaging and streaming platforms such as Apache Kafka
- Selection of suitable database models (relational, key-value-, graph-, document-oriented), necessary consistency level, as well as sharding using the example of PostgreSQL, Neo4J, Apache Cassandra and Redis
- Strategies for caching data, in particular HTTP responses (web caching).

Project

- Be able to formulate and present a research question in the topic area of the course.
- Design an application prototype that serves to investigate the research question.
- Develop the application prototype and run it in the cloud
- Design and conduct test scenarios and experiments with the application prototype to answer the research question.

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Project
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	- advanced programming skills - basic knowledge of web technologies - basic knowledge of databases - basic knowledge in software architectures - basic knowledge of Unified Modeling Language (UML)
Mandatory Prerequisites	Project requires attendance in the amount of: 4 Termine
Capacity-limited admission	no
Recommended Literature	▪ Lecture Notes Large and Cloud-based Software Systems ▪ H. Adkins et al.: Building Secure and Reliable Systems, O'Reilly Media, 2020 ▪ I. Gregorik: High Performance Browser Networking, O'Reilly Media, 2013 ▪ M. Kleppmann: Designing Data-Intensive Applications, O'Reilly Media, 2017
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	

Use of the Module in Other Study Programs	▪ LCSS in Master Communication Systems and Networks PO4 ▪ LCSS in Master Elektrotechnik und Informationstechnik PO1 ▪ LCSS in Master Medientechnologie PO4 ▪ LCSS in Master Technische Informatik PO3 ▪ LCSS in Master Informatik und Systems-Engineering PO1
Permanent Links to Organization	Ilu course
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.25 LSPW - Leistungselektronische Stellglieder für PV- und Windkraftanlagen

Module ID	LSPW
Module Name	Leistungselektronische Stellglieder für PV- und Windkraftanlagen
Type of Module	Elective Modules
Recognized Course	LSPW - Power Electronics for PV and Wind
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Andreas Lohner
Lecturer(s)	Prof. Dr. Christian Dick (Professor Fakultät IME)

Learning Outcome(s)

> Die Studierenden lernen elektronische und elektromagnetische Strukturen, Topologien und Regelungsverfahren verschiedener erneuerbarer Energieerzeugungsanlagen (Photovoltaik & Wind) erläutern, erklären und z. T. auch entwickeln, indem sie
> - die gesamte anlagenspezifische Systemtechnik in wesentliche Teile (Elektromechanik, Leistungselektronik, Steuerung/Regelung) gliedern,
> - Rechnermodelle von allen Teilen und auch der Gesamtanlage entwerfen und mit einem Simulationstool simulieren,
> - mit Leistungselektronik, Antrieben, klassischen Messgeräten umgehen,
> - sowie spezifische Regelungsalgorithmen erkennen und verstehen,
> um als Ingenieure
> - Erneuerbare Energieerzeugungsanlagen zu konzeptionieren und zu dimensionieren,
> - Leistungselektronische Komponenten für EE zu entwickeln und
> - für EE spezifische Regelungen zu entwerfen.

Module Contents

Lecture / Exercises

Overview of the different renewable energy sources and their potentials Photovoltaic, Wind power etc.

Principles of grid-connected as well as of idle solar inverters for photovoltaic systems
Physics of the solar cell
Inverter topologies
System architectures: central, string and module inverters
Control methods: PWM, MPP tracking etc.

Principles of wind turbines
double-fed induction machine
Plant with synchronous machine
Wind power-specific control algorithms

The students will be able to explain electronic and electromagnetic structures, topologies and control methods of various renewable energy generation systems (photovoltaic, wind, etc.).
The students possess the ability to dissect the entire plant-specific system technology into essential subsections, to develop or to project individual aspects and thus to carry out individual steps of a synthesis.
The relationship to reality, in particular with regard to new regulatory, normative framework conditions that accompany the energy transition, is being established. This enables the student to describe the actuators as part of an intelligent network in the superordinate context in order to later select or develop the correct actuators.

The students become acquainted with methods for the dynamic description and regulation of renewable energy generation plants and thereby obtain decision-making authority.
The students have experience in handling power electronics, drives, classical measuring devices and are able to model actuators with a simulation tool.
Students have the ability to understand, dimension and regulate electrical actuators for renewable energy generation.

Lab

In a first experiment, an inverter for a photovoltaic system is modeled as an example and simulated with a simulation tool. Special attention is paid to the plant-specific regulatory procedures (MPP tracking, etc.). Thereafter, a commercial inverter is measured and analyzed.

In a second experiment, a double-fed induction machine including converters is being investigated as an actuator for wind turbines.

Students can handle a standard commercial modeling and simulation tool.
The students understand the working behavior of power electronic actuators.
The students can solve tasks in a small team.
They can analyze measurement results and gain insights into the measurement object.
They can model and simulate a real system.

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Lab
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	Fundamentals of electrical engineering power electronics Basics of electric drives Analogue signals and systems
Mandatory Prerequisites	Lab requires attendance in the amount of: Labortermine (8 Std.)
Capacity-limited admission	no

Recommended Literature	▪ Hau E.: Windkraftanlagen - Grundlagen, Technik, Einsatz, Wirtschaftlichkeit, Springer Verlag ▪ Mertens, K.: Photovoltaik - Lehrbuch zu Grundlagen, Technologie und Praxis, Hanser Verlag ▪ Sahan, B.: Wechselrichtersysteme mit Stromzwischenkreis zur Netzanbindung von Photovoltaik-Generatoren, KDEE Kassel
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ LSPW in Master Communication Systems and Networks PO4 ▪ LSPW in Master Elektrotechnik PO3 ▪ LSPW in Master Elektrotechnik und Informationstechnik PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

Additional module variant with same learning outcomes

Module ID	LSPW
Module Name	Leistungselektronische Stellglieder für PV- und Windkraftanlagen
Type of Module	Elective Modules
Recognized Course	LSPW - Power Electronics for PV and Wind
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Andreas Lohner
Lecturer(s)	Prof. Dr. Christian Dick (Professor Fakultät IME)

Learning Outcome(s)

> Die Studierenden lernen elektronische und elektromagnetische Strukturen, Topologien und Regelungsverfahren verschiedener erneuerbarer Energieerzeugungsanlagen (Photovoltaik & Wind) erläutern, erklären und z. T. auch entwickeln, indem sie
> - die gesamte anlagenspezifische Systemtechnik in wesentliche Teile (Elektromechanik, Leistungselektronik, Steuerung/Regelung) gliedern,
> - Rechnermodelle von allen Teilen und auch der Gesamtanlage entwerfen und mit einem Simulationstool simulieren,
> - mit Leistungselektronik, Antrieben, klassischen Messgeräten umgehen,
> - sowie spezifische Regelungsalgorithmen erkennen und verstehen,
> um als Ingenieure
> - Erneuerbare Energieerzeugungsanlagen zu konzeptionieren und zu dimensionieren,
> - Leistungselektronische Komponenten für EE zu entwickeln und
> - für EE spezifische Regelungen zu entwerfen.

Module Contents

Lecture / Exercises

Overview of the different renewable energy sources and their potentials Photovoltaic, Wind power etc.

Principles of grid-connected as well as of idle solar inverters for photovoltaic systems
Physics of the solar cell
Inverter topologies
System architectures: central, string and module inverters
Control methods: PWM, MPP tracking etc.

Principles of wind turbines
double-fed induction machine
Plant with synchronous machine
Wind power-specific control algorithms

The students will be able to explain electronic and electromagnetic structures, topologies and control methods of various renewable energy generation systems (photovoltaic, wind, etc.).
The students possess the ability to dissect the entire plant-specific system technology into essential subsections, to develop or to project individual aspects and thus to carry out individual steps of a synthesis.
The relationship to reality, in particular with regard to new regulatory, normative framework conditions that accompany the energy transition, is being established. This enables the student to describe the actuators as part of an intelligent network in the superordinate context in order to later select or develop the correct actuators.

The students become acquainted with methods for the dynamic description and regulation of renewable energy generation plants and thereby obtain decision-making authority.
The students have experience in handling power electronics, drives, classical measuring devices and are able to model actuators with a simulation tool.
Students have the ability to understand, dimension and regulate electrical actuators for renewable energy generation.

Lab

In a first experiment, an inverter for a photovoltaic system is modeled as an example and simulated with a simulation tool. Special attention is paid to the plant-specific regulatory procedures (MPP tracking, etc.). Thereafter, a commercial inverter is measured and analyzed.

In a second experiment, a double-fed induction machine including converters is being investigated as an actuator for wind turbines.

Students can handle a standard commercial modeling and simulation tool.
The students understand the working behavior of power electronic actuators.
The students can solve tasks in a small team.
They can analyze measurement results and gain insights into the measurement object.
They can model and simulate a real system.

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Lab
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	Fundamentals of electrical engineering power electronics Basics of electric drives Analogue signals and systems
Mandatory Prerequisites	Lab requires attendance in the amount of: 8 Unterrichtsstunden
Capacity-limited admission	no

Recommended Literature	▪ Hau E.: Windkraftanlagen - Grundlagen, Technik, Einsatz, Wirtschaftlichkeit, Springer Verlag ▪ Mertens, K.: Photovoltaik - Lehrbuch zu Grundlagen, Technologie und Praxis, Hanser Verlag ▪ Sahan, B.: Wechselrichtersysteme mit Stromzwischenkreis zur Netzanbindung von Photovoltaik-Generatoren, KDEE Kassel
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ LSPW in Master Communication Systems and Networks PO4 ▪ LSPW in Master Elektrotechnik PO3 ▪ LSPW in Master Elektrotechnik und Informationstechnik PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.26 MAA - Masterarbeit

Module ID	MAA
Module Name	Masterarbeit
Type of Module	Mandatory Module
Recognized Course	MAA - Master thesis
ECTS credits	27
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	3
Frequency of Course	every term
Module Coordinator	Studiengangsleiter(in) Master Technische Informatik (Informatik und Systems-Engineering)
Lecturer(s)	verschiedene Dozenten*innen (diverse lecturers)

Learning Outcome(s)

> Das Modul vermittelt folgende Kenntnisse und Fertigkeiten:
> - Komplexe Aufgabenstellungen beurteilen
> - Selbständiges Verfassen eines längeren wissenschaftlichen Textes
> - Gute Praxis des wissenschaftlichen Arbeitens anwenden
> - Darstellung von Forschungsergebnissen in Form eines wissenschaftlichen Artikels nach den Vorgaben gängiger Fachzeitschriften bzw. Konferenzen
> - Selbstständiges und systematisches Bearbeiten einer komplexen ingenieurwissenschaftlichen Aufgabenstellung unter Verwendung wissenschaftlicher Methoden
> - Lösungsstrategien entwickeln und umsetzen
> - Wissenschaftliche Literatur recherchieren und auswerten
> - Eigene Arbeit bewerten und einordnen
>
> Individuelle Vereinbarung des Studierenden mit einem Dozenten der MT bzw. F07 über eine qualifizierte Ingenieurtätigkeit mit einer studiengangsbezogenen Aufgabenstellung mit wissenschaftlichem Anspruch. Die Masterarbeit kann auch extern in einer Forschungsorganisation, einem Wirtschaftsunternehmen o.ä. durchgeführt werden. Die Betreuung erfolgt durch den Dozenten.
> Die Masterarbeit addressiert die Entwicklung komplexer Medientechnologien unter interdisziplinären Bedingungen (HF1) und das wissenschaftliche Arbeiten um wissenschaftliche Erkenntnisse zu erweitern (HF2)."

Module Contents

Thesis

> The Master's thesis is a written assignment. It should show that the student is capable of independently working on a topic from his or her subject area within a specified period of time, both in its technical details and in its interdisciplinary contexts, using scientific and practical methods. Interdisciplinary cooperation can also be taken into account in the final thesis.

Teaching and Learning Methods	Thesis
Examination Types with Weights	cf. exam regulations
Workload	810 Hours
Contact Hours	0 Hours ≙ 0 SWS
Self-Study	810 Hours
Recommended Prerequisites	See examination regulations §26
Mandatory Prerequisites	see exam regulations §26 paragraph 1

Capacity-limited admission	no
Recommended Literature	
Included in Elective Catalog	
Included in Specialization	
Use of the Module in Other Study Programs	▪ MAA in Master Communication Systems and Networks PO4 ▪ MAA in Master Elektrotechnik PO3 ▪ MAA in Master Elektrotechnik und Informationstechnik PO1 ▪ MAA in Master Medientechnologie PO3 ▪ MAA in Master Medientechnologie PO4 ▪ MAA in Master Technische Informatik PO3 ▪ MAA in Master Informatik und Systems-Engineering PO1
Specifics and Notes	See also examination regulations §24ff. Contact a professor of the faculty early on for the initial supervision of the thesis.
Last Update	14.11.2025, 08:32:05

6.27 MCI - Mensch-Computer-Interaktion

Module ID	MCI
Module Name	Mensch-Computer-Interaktion
Type of Module	Elective Modules
Recognized Course	MCI - Human Computer Interaction
ECTS credits	5
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Jonas Schild
Lecturer(s)	Prof. Dr. Jonas Schild (Professor Fakultät IME)

Learning Outcome(s)

WAS:
Das Modul vermittelt folgende Kenntnisse und Fertigkeiten:
- Grundlagen der Mensch-Computer-Interaktion: Definitionen, Normen, Modelle, Prinzipien
- Interaktive Systeme aus Hard- und Software konzipieren, implementieren und analysieren
- User Experience verstehen und Prinzipien des UX Engineerings anwenden
- Wiss. Fragestellungen vor einem Forschungshintergrund der HCI entwickeln
- Geeignete Nutzerstudien nach wiss. und ethischen Kriterien konzipieren, planen und durchführen
- statistische und deskriptive Daten wissenschaftlich analysieren, veranschaulichen und diskutieren
- in heterogenen Teams zusammenarbeiten, sich koordinieren und präsentieren

WOMIT:
Die Kompetenzen werden zunächst über eine Vorlesung durch die Dozenten vermittelt und danach im Praktikum anhand konkreter Aufgabenstellung von den Studierenden vertieft. Im seminaristischen Teil der Lehrveranstaltung recherieren die Studierenden zu vorgegebenen Themen anhand von Fachartikeln und weiteren Informationsquellen über neue Konzepte der Mensch-Computer Interaktion und stelle diese dar in einer Präsentation dar.

WOZU:
Die Studierenden erlernen das eigenständige Durchführen von Forschungsprozesse auf dem Gebiet der Mensch-Computer-Interaktion, um im interdisziplinären Team auf Grundlage von selbst entwickelten komplexen, interaktiven Systemen (HF1) aktuelle Fragestellungen aus dem Bereich der Mensch-Computer-Interaktion wissenschaftlich untersuchen (HF2) und dabei die Effektivität und Wirkung von interaktiven Systemen auf Nutzende testen und einschätzen zu können (HF4).

Module Contents

Lecture

Models and design principles of interactive systems
Principles of context-, task- and user-oriented development of interactive systems
Basics of barrier-free access to interactive systems
Relevant standards and guidelines: EN ISO 9241, ISO 14915, HHS
Control options: Dedicated input/output devices, voice control, gesture control
Best Practices and Style Guides: Desktop / Web / Mobile / Hybrid Applications
Usability evaluation (analytical/empirical, heuristics, expert interviews, focus groups, user studies)
Evaluation methods (thinking aloud, eye-tracking, (semi-)structured interviews)

Experimental Research: Research Question, Hypotheses, Errors of 1st and 2nd Kind
Experiment Design: Between Group, Within Group, Split-Plot, Reliability of Experimental Results
Statistical analysis: scale levels, descriptive statistics, T-tests, ANOVA, regression, correlation
Surveys: sampling and sample selection, sources of error, questionnaires, evaluation of surveys

Lab

Capturing and understanding textual tasks
Recording tasks and creating models from them
Implementing UI components on the basis of the models created
Testing and securing developments
Checking and evaluating work results of comolitons
Applying MCI research methods and terminology

Seminar

Teaching and Learning Methods	▪ Lecture ▪ Lab ▪ Seminar
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	none
Mandatory Prerequisites	▪ Lab requires attendance in the amount of: 2 Termine ▪ Seminar requires attendance in the amount of: Vorträge und Schlusspräsentation
Capacity-limited admission	no
Recommended Literature	▪ A. M. Heinecke: Mensch-Computer-Interaktion, Basiswissen für Entwickler und Gestalter, 2. Auflage, Springer, 2011 ▪ B. Shneiderman, C. Plaisant: Designing the User Interface: Strategies for Effective Human-Computer Interaction, Addison Wesley, 2009 ▪ S. Swink: Game Feel: A Game Designer's Guide to Virtual Sensation, Morgan Kaufmann Game Design Books, 2008 ▪ T. Sylvester: Designing Games: A Guide to Engineering Experiences, O'Reilly, 2013 ▪ J. Lazar, J.H. Feng, H. Hochheiser, Research Methods in Human-Computer-Interaction, Wiley, 2012

Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ MCI in Master Communication Systems and Networks PO4 ▪ MCI in Master Medientechnologie PO3 ▪ MCI in Master Medientechnologie PO4 ▪ MCI in Master Technische Informatik PO3 ▪ MCI in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.28 MLWR - Maschinelles Lernen und wissenschaftliches Rechnen

Module ID	MLWR
Module Name	Maschinelles Lernen und wissenschaftliches Rechnen
Type of Module	Elective Modules
Recognized Course	MLWR - Machine Learning and Scientific Computing
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Beate Rhein
Lecturer(s)	Prof. Dr. Beate Rhein (Professorin Fakultät IME)

Learning Outcome(s)

> Was:
> fortgeschrittene Methoden des maschinellen Lernens auf typische Datensätze der technischen Informatik anwenden
> Fallstricke des Maschinellen Lernens in der Vorgehensweise erkennen
> für eine Aufgabenstellung das geeignete Verfahren bestimmen und anwenden können
> Qualität von Datensätzen beurteilen und verbessern
> Datenschutzgesetze kennen
> weit verbreitete Software des maschinellen Lernens anwenden
>
> Womit:
> Die Methoden werden anhand eines Vortrags oder per Lernvideos vermittelt und in Vorlesung und Übung direkt angewendet. Jeder Student wird ein Projekt durchführen (je nach Anzahl der Studierenden in Gruppenarbeit), bei der er sich Teile des Stoffes selber erarbeitet.
>
> Wozu:
> Maschinelles Lernen wird bei den späteren Arbeitgebern immer mehr eingeführt, etwa in der Robotik, aber auch zur Überwachung und Steuerung von Produktionsprozessen oder Energiesystemen und zur Auswertung von Kundendaten, hier ist ein verantwortlicher Einsatz von Daten wichtig.

Module Contents

Lecture / Exercises

> Approximation methods
> metamodeling
> regression
>
> Multi-criteria optimization
> formulation
> Pareto front
> algorithms
> visualization
>
> Advanced Cluster Analysis
>
> Association Pattern Mining
>
> Outlier Detection
>
> Advanced classification procedures
>
> possibly text recognition, web mining, time series analysis

Lab

> Apply and program methods of approximation, multicriteria optimization or machine learning
> efficiently implement numerical methods
> Evaluate the complexity of algorithms

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Lab
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	Basic knowledge of probability theory and machine learning
Mandatory Prerequisites	▪ Lecture / Exercises requires attendance in the amount of: 6 Stunden ▪ Lab requires attendance in the amount of: 2 Termine ▪ Participation in final examination only after successful participation in Lab
Capacity-limited admission	no
Recommended Literature	▪ A. Geron: Hand-on Machine Learning, O'Reilly Verlag ▪ J. Alammar: Hands-on Large Language Models, O'Reilly Verlag
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2 ▪ PFM - Profile Module
Included in Specialization	CS - Communication Systems

Use of the Module in Other Study Programs	▪ MLWR in Master Elektrotechnik PO3 ▪ MLWR in Master Elektrotechnik und Informationstechnik PO1 ▪ MLWR in Master Medientechnologie PO4 ▪ MLWR in Master Technische Informatik PO3 ▪ MLWR in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.29 NGN - Next Generation Networks

Module ID	NGN
Module Name	Next Generation Networks
Type of Module	Elective Modules
Recognized Course	NGN - Next Generation Networks
ECTS credits	5
Language	englisch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Andreas Grebe
Lecturer(s)	Prof. Dr. Andreas Grebe (Professor Fakultät IME)

Learning Outcome(s)

> What?
> Understanding architectures and service signalling in Next Generation Networks (All-IP Networks). Competences to evaluate, analyze, design, implement and test NGN components and service areas with heterogeneous service requirements.
> How?
> Based on Bachelor-level competences on IP networking and services, students learn standards, design principles, architectures and sample implementations of Next Generation Networks and serivces in lectures and exercises. In a small team and organized as semester project, students develop their own NGN service solution, optionally based and on existing systems, and learn how to design, implementnt and anlysze their own service solution.
> What for?
> To be able to design, analyze, select, use and apply actual and future network servces, based on All-IP networks for enterprise networks, telecommunication networks and mobile networks.

Module Contents

Lecture / Exercises

> Achive basic understanding and implementation knowledge on Next Generation Network (NGN) defintion by ITU-T, IP Multimedia Subsystem by 3GPP, and ETSI, and Next Generation Internet (NGI) definition by IETF, ITU-T standards, Multimedia Services in NGN, VoIP, Video-over-IP, RTP encaplsulation, Service Signaling, SIP protocol, SIP Digest Authentication, SDP service description and capabilities, SIP servers, Session Border Controller (SBC), SIP Gateway Technologies, SIP routing, NAT Gateways, NAT solution, SRR, STUN , TURN, IMS in mobile networks, IMS in fixed-line networks, VoIP in enterprise networks. IMS in virtualized core network.

> Students evaluate requirements for NGN services and plan, implement and analyze NGN services based on SIP signalling or alternative signalling protocols. They are competent in functional analysis and troubleshooting by deep packet inspection (DPI) protocol analysis. They evaluate the performance of NGN services in terms of timing, throughput, latency and delays, jitter, robustness in case of packet errors, and security aspects.

Lab

> Naming, structuring and classifying concepts and technologies for NGNs or NGIs. Demonstrate network analysis techniques and tools, know methods for NGN services and network planning.

> Working on a small project in a tiny team (2-3 team members) on actual technologies in the area of NGN services and NGI services. Set-up an NGN/NGI environment and NGN service, including planning, implementation and evaluation of security aspects and protocol anlaysis plus performance evaluation.
> The results are reviewed during the course period, summarised in a report and presented to the class. Individual project proposals by students are wellcome.

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Lab

Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	▪ Modul BSN: Bachelor Level Networking Knowledge and Skills like teached in BSN. Fundamentals of Networks and Protocols (typically Bachelor Level) Layered Communications and Protocol Stacks (ISO/OSI, IETF TCP/IP, IEEE), LAN, MAN, WAN, Fixed Line and Mobile Network Fundamentals, Data Link-Technologies (Ethernet, WiFi), IP-Networking (IPv4, IPv6), IP Routing Protocols (static Routes, RIP, OSPF, BGP), Transport Protocols (TCP (incl. Flow Control / Congestion Control), UDP) and Port Numbers, Application Protocols (HTTP, Request-Response Pattern, Publish-Subscribe Pattern). ▪ Bachelor-level knowledge of protocols and layer models, Internet protocols (UDP, TCP, IP, HTTP, FTP), IP addressing (IPv4, IPv6), routing techniques (IP routing, functionality of a router, routing protocols, RIP, OSPF), transmission systems and layer 2 protocols, Ethernet. Understanding distributed systems and applications, sockets and client/server programming, request-response patterns, publishg-subscribe patterns.
Mandatory Prerequisites	▪ Lab requires attendance in the amount of: 6 Meilensteintermine und Projektvorstellungen ▪ Participation in final examination only after successful participation in Lab
Capacity-limited admission	yes, according to approved request
Recommended Literature	▪ J. Kurose, K. Ross: Computer Networking: A Top-Down Approach, Global Edition, Prentice Hall, 7th ed., 2016 ▪ A. S. Tanenbaum, D. J. Wetherall: Computer Networks, Pearson , 5th ed., 2013 ▪ U.Trick, F. Weber: SIP und Telekommunikationsnetze: Next Generation Networks und Multimedia over IP – konkret, De Gruyter Oldenbourg Verlag, 4. Auflage 2015 ▪ J. F. Durkin: Voice-enabling the Data Network,Cisco Press 2010 ▪ G. Camarillo, M.A. García-Martín: The 3G IP Multimedia Subsystem (IMS), John Wiley Verlag, 2006 ▪ W. Stallings: Foundations of Modern Networking, Pearson Education, 2016 ▪ J. Doherty: SDN and NFV Simplified, Pearson Education, 2016 ▪ J. Edelman: Network Programmability and Automation, O'Reilly 2018 ▪ J. van Meggelen, R. Bryant, L. Madsen: Asterisk: The Definitive Guide: Open Source Telephony for the Enterprise, O'Reilly Media, 5th Ed. 2019
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2 ▪ PFM - Profile Module
Included in Specialization	▪ CS - Communication Systems ▪ N_S - Networks & Security
Use of the Module in Other Study Programs	▪ NGN in Master Communication Systems and Networks PO4 ▪ NGN in Master Elektrotechnik und Informationstechnik PO1 ▪ NGN in Master Technische Informatik PO3 ▪ NGN in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	22.10.2025, 11:22:18

6.30 NLO - Nichtlineare Optik

Module ID	NLO
Module Name	Nichtlineare Optik
Type of Module	Elective Modules
Recognized Course	NLO - Nonlinear optics
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Uwe Oberheide
Lecturer(s)	Prof. Dr. Uwe Oberheide (Professor Fakultät IME)

Learning Outcome(s)

> Die Studierenden verstehen die grundlegenden Eigenschaften von Licht und Materie bei hohen Lichtintensitäten,
> indem sie die zugrunde liegenden Prozesse mathematisch, physikalisch und technisch analysieren und in idealisierter Umgebung beschreiben,
> damit sie in ihrer Abschlussarbeit und Berufsalltag passende Komponenten und Verfahren zur Lichtbeeinflussung und Materialbearbeitung inbesondere mit ultrakurzen Laserpulsen auswählen können.

Module Contents

Lecture / Exercises

Optical frequency multiplication (crystal coherence lengths, phase matching,
quasi phase matching and periodic polarity)
Frequency mixing
Optical-parametric oscillation and amplification
Electro-, magneto- and acousto-optical effects
Q-switch, mode coupling, ultrashort pulse laser
Application of multiphoton processes
Photorefraction, stimulated Brillouin scattering, phase conjugating mirrors

Recognizing analogies of known linear physical processes (light-matter interaction at low intensity) and transferring them to nonlinear processes
Describe processes mathematically and transfer the result into physical effects
Transfer idealized systems to real systems and derive qualitative behavior
Describe and explain correlations of quantities (saturable absorption / multidimensional refractive index) and transfer them to real materials.
Analyze technical applications and problems, break them down into individual processes and solve them using known nonlinear interactions.

Seminar

Presentations on applications/processes based on the content of the course (transfer of course content to other applications).
Examples:
- spectral broadening in a femtosecond laser by self-phase modulation
- temporal measurement of ultrashort laser pulses
- compensation of imaging errors by the use of phase conjugating mirrors
- laser induced nuclear fusion
- multiphoton processes
- generation and application of higher harmonics
- optical parametric oscillators
- free-electron laser

Procurement of suitable literature/information
Familiarisation with new technical field of expertise
Use of english technical literature
Evaluation of available literature
Checking the relevance of information
Filtering out essential information and preparing it for the appropriate target group

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Seminar
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	Physics: wave propagation, phase velocity Laser technology: laser types, basic principle of stimulated emission Light-matter interaction: absorption, scattering, refractive index, birefringence
Mandatory Prerequisites	Seminar requires attendance in the amount of: Vortragstermine
Capacity-limited admission	no

Recommended Literature	▪ Boyd – Nonlinear Optics, Elsevier ▪ Pedrotti – Optik für Ingenieure, Springer ▪ Saleh, Teich – Grundlagen der Photonik, Wiley VCH
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ NLO in Master Communication Systems and Networks PO4 ▪ NLO in Master Elektrotechnik PO3 ▪ NLO in Master Elektrotechnik und Informationstechnik PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.31 OSA - Optische Spektroskopie und Anwendungen

Module ID	OSA
Module Name	Optische Spektroskopie und Anwendungen
Type of Module	Elective Modules
Recognized Course	OSA - Optical Spectroscopy and Applications
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Michael Gartz
Lecturer(s)	Prof. Dr. Michael Gartz (Professor Fakultät IME)

Learning Outcome(s)

> Was: Die Studierenden können optische Messprobleme analysieren und eigene Spektrometer-Systeme synthetisieren und hinsichtlich der optischen und wirtschaftlichen Eigenschaften bewerten. Sie können Spektrometer designen, konstruieren, realisieren und damit die aus den Kundenanforderungen extrahierten Messgrößen optimal bestimmen und die Ergebnisse interpretieren.
> Womit: indem die Studierenden mittels der Projektarbeit die in den Vorlesungen vermittelten Theorien anwenden, beurteilen und bewerten, mittels eigener Recherchen und Projektbesprechungen ihren Lösungsansatz entwickeln, realisieren und in eigenen Vorträgen darstellen, präsentieren und bewerten,
> Wozu: um später in Entwicklungsabteilungen von optischen Messtechnikunternehmen Messprobleme zu verstehen, zu analysieren, konstruktive Lösungen zu erarbeiten und zu realisieren bis zum serienreifen Endprodukt. Um als beratende Ingenieure Kundenprobleme zu analysieren und mit am Markt befindlichen Systemen Applikationen zu erstellen, die die optischen Messprobleme lösen oder am Markt befindliche Messsysteme beurteilen und bewerten können, ob sie zur Lösung geeignet sind. Um erarbeitete oder bewertete optische Lösungen wissenschaftlich einwandfrei zu präsentieren.

Module Contents

Lecture

First application
Layer thickness measurement by optical sepktroscopy
measuring principle
superstructure
sensitivity

Basics of spectroscopy
dispersion
angular dispersion
linear dispersion
prism
Beam path in prism
Dispersion of the prism
diffraction grating
Diffraction at the grating
Dispersion at the grating
usable spectral range of the grating
grating types
transmission grating
reflection grating
echelette grating
concave grating
manufacturing techniques
scored gratings
holographic gratings
Diffraction efficiency of gratings
measurement
Blaze Technique
Comparison: grating and prism

Structure of spectrometers
Structure of the monochromator
Structure of the prism spectrometer
resolving capacity of the prism spectrometer
beam path
Structure of the grating spectrometer
resolving capacity of the grating spectrometer
beam path
negative effects in the spectrometer
ghost images
scattered light
Second Order Effects
radiation sources
Properties of radiation sources
Thermal sources
discharge lamps
light-emitting diodes
laser
Detectors / Receivers
Properties of Receivers
photodiode
CCD / CMOS line / matrix
thermal detectors
filters
absorption filter
interference filters
Calibration of spectrometers

wavelength calibration
intensity calibration

Characteristics of spectrometers
Spectral resolution capability
diffraction efficiency
free spectral range

Commercial spectrometers
UV spectrometer
VIS spectrometer
IR / NIR spectrometer
Multichannel Spectrometer

Fourier spectroscopy
Principle of Fourier Spectroscopy
Fourier transform
Discrete Fourier transformation
Fourier spectrometer

applications
Raman spectroscopy
fundamentals
Applications of Raman spectroscopy
colorimetry
transmission measurement
remission measurement
emission measurement
coating thickness measurement
Spectral Element Analysis
(further topics according to selection)

calculate
the spectral resolution
angular and linear dispersion
of the free spectral range
the working range of the chromatic longitudinal aberration sensor
the resolution of the light section sensor

select
a spectrometer for a special measuring task
a light source for absorption and
transmission measurements

determine
the transmission curve of various optical components
the spectral reflectance
the thickness of non-opaque layers

assess
the sensitivity of a spectrometer
the usability of a spectrometer

analyze
of measuring tasks from the field of optical
spectroscopy

Project

Adjusting spectrometer superstructures

record, evaluate and document optical spectra

Check results for plausibility

Recognizing and understanding interrelationships

Selecting the spectrometer type for a specific measurement task

Calculation of the different spectral display modes

analyse a spectroscopic optical measuring task
Independently recognized measuring task can be analyzed
a given measuring task can be analyzed

design a solution approach for the analyzed optical measuring task
Consideration of laboratory resources
Consideration of the available time quota

Presentation of a project outline
Describe the task
outline the approach
Present results in a clearly structured way
Discuss results in technical and scientific manner

Milestone presentation to check the progress of the project
Describe the task
outline the approach
Present results in a clearly structured way
Discuss results in technical and scientific manner

Final presentation with presentation of the realized solution approach
Describe the task
outline the approach
Present results in a clearly structured way
Discuss results in technical and scientific manner

basic spectrometer setups can be realized by yourself
build
adjust
Carry out function test

investigate scientific/technical principles with an optical structure
Plan measurement series
Estimate error influences
Check the suitability of the superstructure

Evaluate self-acquired measurement series
Graphic display of measured values
Calculate implicit quantities from measured values math.
correctly
discover and name logical errors
Simulate measured values using predefined formulas

Work on complex technical tasks in a team
Organize into subtasks
Discuss measurement results
complement each other meaningfully

Teaching and Learning Methods	▪ Lecture ▪ Project
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	34 Hours ≙ 3 SWS
Self-Study	116 Hours
Recommended Prerequisites	Geometric optics radiometry, photometry, radiation physics Optical metrology wave optics Mathematics 1 / 2 Physics 1 / 2

Mandatory Prerequisites	▪ Project requires attendance in the amount of: 3 Projektpräsentationen ▪ Participation in final examination only after successful participation in Project
Capacity-limited admission	no
Recommended Literature	▪ Demtröder, Laser-Spektroskopie, Springer ▪ Demtröder, Experimentalphysik 2, Springer ▪ Schmidt Werner, Optische Spektroskopie, Wiley-VCH ▪ Pedrotti, Pedrotti, Bausch, Schmidt, Optik für Ingenieure, Grundlagen, Springer ▪ Schröder, Treiber, Technische Optik, Vogel Verlag ▪ Hecht, Optik, Oldenbourg ▪ Bergmann, Schaefer, Bd.3, Optik, de Gruyter ▪ Max Born und Emil Wolf, Principles of Optics, Cambridge University Press
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ OSA in Master Communication Systems and Networks PO4 ▪ OSA in Master Elektrotechnik PO3 ▪ OSA in Master Elektrotechnik und Informationstechnik PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.32 PAP - Parallele Programmierung

Module ID	PAP
Module Name	Parallele Programmierung
Type of Module	Elective Modules
Recognized Course	PAP - Parallel Programming
ECTS credits	5
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr.-Ing. Arnulph Fuhrmann
Lecturer(s)	Prof. Dr.-Ing. Arnulph Fuhrmann (Professor Fakultät IME)

Learning Outcome(s)

Medientechnische und interaktive Systeme beinhalten rechenintensive Berechnungen. Um Anforderungen an die Verarbeitung in Echtzeit erfüllen zu können, sind daher Kompetenzen und Wissen über die Grundlagen für die Analyse (HF1, HF2), den Entwurf (HF1, HF2), die Implementierung (HF1, HF2) und die Bewertung (HF1, HF2) paralleler Computerprogramme erforderlich.

Folgende Kenntnisse und Kompetenzen werden im Detail vermittelt:
- Grundlegende Konzepte, Modelle und Technologien der parallel Verarbeitung benennen, strukturieren, einordnen und abgrenzen
- Aufgabenstellungen in Bezug auf die Programmierung paralleler Programme analysieren und strukturieren, einschlägige parallele Hardwarearchitektur zuordnen und auf Paralleldesign übertragen
- Parallele Programme unter Einsatz geeigneter Tools analysieren und Ergebnisse nachvollziehbar darstellen
- Leistungsfähigkeit paralleler Programme abschätzen und analysieren
- Information aus englischen Originalquellen und Standards ableiten

Kenntnisse und Basisfertigkeiten werden in der Vorlesung vermittelt. Begleitend dazu werden in den Übungen Kompetenzen und Fertigkeiten ausgebaut und inhaltliche Themen vertieft.

Module Contents

Lecture

- Basic concepts, models and technologies of parallel processing (parallelism, concurrency, SISD, SIMD, MISD, MIMD, loose- and closely coupled systems, distributed systems)
- Parallel performance measures (speedup, efficiency)
- Architecture of GPUs
- Parallel Algorithms for GPUs

Exercises / Lab

- Analyze and structure tasks related to programming parallel programs, assign relevant parallel hardware architecture and transfer to parallel design
- Implement parallel programs (multicore hardware with threads and GPUs)
- Analyze parallel programs using suitable tools and present results in a comprehensible way
- Estimate and analyze performance of parallel programs
- Derive information from original English sources and standards

Teaching and Learning Methods	▪ Lecture ▪ Exercises / Lab
Examination Types with Weights	cf. exam regulations

Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	The exercises require programming knowledge and the use of console-oriented programs in Linux-based operating systems.
Mandatory Prerequisites	Exercises / Lab requires attendance in the amount of: 2 Termine
Capacity-limited admission	no
Recommended Literature	▪ Wen-mei W. Hwu, David B. Kirk, Izzat El Hajj: Programming Massively Parallel Processors A Hands-on Approach - 4th Edition, 2022 ▪ Andrew S. Tanenbaum, Herbert Bos: Modern Operating Systems, 4th Edition, 2015 ▪ Jason Sanders: CUDA by Example: An Introduction to General-Purpose GPU Programming, Addison-Wesley Longman, 2010 ▪ R. Oechsle: Parallele und verteilte Anwendungen in Java, Hanser, 2011 ▪ P. Pacheco: An Introduction to Parallel Programming, Morgan Kaufmann, 2011
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ PAP in Master Communication Systems and Networks PO4 ▪ PAP in Master Medientechnologie PO3 ▪ PAP in Master Medientechnologie PO4 ▪ PAP in Master Technische Informatik PO3 ▪ PAP in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.33 PM - Project Management

Module ID	PM
Module Name	Project Management
Type of Module	Mandatory Module
Recognized Course	PM - Project Management
ECTS credits	5
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	1
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Uwe Dettmar
Lecturer(s)	Said Erkan (Lehrbeauftragter)

Learning Outcome(s)

> What? Learn how to create a project plan as part of their study
>
> How? by applying project management concepts and processes to their "real-life" projects allowing them to generate immediate results that are usable in their future business situation. It acquires hands-on experience in applying new concepts and techniques in a project team environment and gain the confidence to take this forward to their environment.
>
> Why? To be prepared managing projects during their work life of proficiency.

Module Contents

Seminar

> Students learn basic PM methods, PM organizations, PM Tools
> Project Management Fundamentals, and Project Initiation based on the PMI curriculum by presentations and team work, and source browsing.

Project

> Practice project management concepts and processes to their "real-life" projects in classroom and team work and One by One sessions. Learn about planning, execution, controlling, and closing a project

Teaching and Learning Methods	▪ Seminar ▪ Project
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	23 Hours ≙ 2 SWS
Self-Study	127 Hours
Recommended Prerequisites	Some basic knowledge on project management
Mandatory Prerequisites	
Capacity-limited admission	no

Recommended Literature	▪ PMP Handbook ▪ www.scrumalliance.org
Included in Elective Catalog	
Included in Specialization	
Use of the Module in Other Study Programs	PM in Master Communication Systems and Networks PO4
Specifics and Notes	
Last Update	21.9.2025, 19:12:28

6.34 QEKS (SEKM) - Qualitätsgesteuerter Entwurf komplexer Softwaresysteme

Module ID	QEKS
Module Name	Qualitätsgesteuerter Entwurf komplexer Softwaresysteme
Type of Module	Elective Modules
Recognized Course	SEKM - Software Engineering by Components and Pattern
ECTS credits	5
Language	deutsch und englisch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Stefan Kreiser
Lecturer(s)	Prof. Dr. Stefan Kreiser (Professor Fakultät IME)

Learning Outcome(s)

> Studierende sind im Hinblick auf die Qualität eines Softwaresystems in der Lage:
> - zur vorhersagbaren, effizienten Entwicklung eines Softwaresystems bzw. einer Softwarearchitektur zielgerichtet angemessene Wiederverwendungsstrategien und professionelle Modellierungs- und Entwicklungswerkzeuge sowie den Rahmenbedingungen insgesamt angemessene Projektstrukturen einzusetzen.
> - die Softwarearchitektur für komplexe, verteilte Automatisierungssysteme unter Berücksichtigung der spezifischen Anforderungen hinsichtlich der besonderen Zielsetzung des jeweiligen Automatisierungssystems zu analysieren, zu konzipieren, zu entwerfen, zu implementieren, zu prüfen und zu bewerten.
> - die besonderen Anforderungen an die Servicequalität, an die Einsatzumgebung und die organisatorischen Rahmenbedingungen für die Entwicklung, die sich aus dem Entwicklungsprozess und einem angemessenen Lebenszyklusmanagement ergeben, zu erkennen und im Hinblick auf ihre Relevanz für die Softwarearchitektur des Automatisierungssystems zu analysieren und zu bewerten.

Module Contents

Lecture / Exercises

Terminology
value vs. cost of a technical software
distributed software system, concurrency
software quality, quality of service, refactoring
complexity (algorithmic, structural), emergence
re-use, symmetry and symmetry operations, abstraction, invariants
quality controlled re-use, methodical approaches
variants of white box re-use
black box re-use
grey box re-use (hierarchical approach to re-use)
re-use in automation control software systems
determinism
benefits and challenges
tailoring process models and personnel structures in projects
meet requirements in development projects predictably (product quality, cost, deadlines)
distributed development, maintenance and support of software systems
software pattern
pattern description using UML
essential architectural pattern
construction pattern
structural pattern
behavioural pattern
class based (static) vs. object based (dynamic) pattern
essential pattern for concurrent and networked real time systems
encapsulation and role based extension of layered architectures
concurrency structures to optimize throughput and system response latency
distributed event processing
process synchronisation
construction and use of pattern catalogues, pattern languages
pattern based design of complex software systems
components and frameworks
design principles
interface architectur
active and passive system elements
design, programming and test
quality
configuration and use
using middleware systems to develop architectures of technical software systems
ORB architectures, e.g. CORBA and TAO
integrated system plattforms, e.g. MS .NET
multi agent systems (MAS)
agent architectural models
collaboration between agents
agent languages
considering cases for MAS application

use pattern to design complex software systems
extract and discuss purpose, limitation of use, invariant and configurable parts of pattern from english and german literature sources
understand implementation skeletons of pattern and map them to problem settings with limited technical focus
discuss benefits of using object oriented programming languages
derive recurrent settings in the development of complex software systems
implement pattern on exemplary settings and test resulting implementations
reasonably combine pattern to solve recurring problem settings with a broader technical focus
use UML2 notations
use professional UML2 IDE for round-trip-engineering
integrate software system based on exemplary implementations of the pattern to combine
conduct integration test, assess software quality and optimize software system

construct black-box-components based on pattern
analyse component based software architectures
derive suitable scope from architectural specs
understand and discuss development process to construct software systems
find active and passive system elements and derive system run time behaviour
understand abstract system interfaces to interconnect, configure and activate components
understand abstract system interfaces to exchange applicational run time data
understand system extension points (functional and structural system configuration layer)
analyse distribution architectures
understand basic system services (describe and reason service usage, relate to system tasks)
relate pattern to structure making architectural software artefacts
derive suitable range of appications for a given distribution architecture
understand engineering process to construct user applications (application layer)
discuss attributes and limitation of usage of interconnection protocols
find designated system extension points
compare MAS to conventional distribution architectures
agent vs. component
architectural models
activation of agents
deployment of agents
protocols for interconnection and collaboration
range of appications and and limitation of usage

Seminar

challenging seminar topics can be defined e.g. from the following or related subject areas
- reusable artifacts for building the architecture of distributed software systems,
- professional distribution architectures,
- Multiagent systems,
- special economic, liability and ethical requirements for software systems with (distributed) artificial intelligence and their effects on the design of software architectures

present personal work results and work results of the team in a compact and target-group-oriented way, both orally and in writing

Project

Develop software artifact of a distribution architecture for complex software systems
Carry out project planning in distributed teams with an agile process model
Perform extensive system analysis with respect to the role of the artifact in the distribution architecture
Determine design input requirements for the development of the artifact
Specify and model the software artifact based on the design input requirements
Select and justify design principles and patterns to achieve defined quality objectives
Derive interfaces, behavioral and structural models iterativly based on patterns in UML2 notations
Use professional UML2 design tool purposefully
Verify and evaluate models, correct model errors and optimize models
Programming software artifacts in C++
define meaningful test scenarios and verify software artifacts
Evaluate the quality of the software artifact
Present the team's project results to a professional audience in a compact and target-group-oriented way

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Seminar ▪ Project
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	57 Hours ≙ 5 SWS
Self-Study	93 Hours

Recommended Prerequisites	▪ Modul PLET: oder aus einem (naturwissenschaftlich-technischen) Bachelorstudium: - grundlegende Kenntnisse in (agilem) Projektmanagement ▪ - programming skills in an object-oriented programming language, preferably C++ - knowledge of software modeling using Unified Modeling Language (UML) or other (formal) languages that support modeling of interfaces, behavior and structures - basic knowledge in (agile) project management, SCRUM oder XP - basic knowledge of essential softare architectural models - basic knowledge of interconnection models in software systems (OSI, TCPIP, Messaging)
Mandatory Prerequisites	▪ Project requires attendance in the amount of: 3 Termine ▪ Participation in final examination only after successful participation in Project
Capacity-limited admission	yes, according to approved request
Recommended Literature	▪ D. Schmidt et.al.: Pattern-Oriented Software Architecture. Patterns for Concurrent and Networked Objects (Wiley) ▪ Gamma et.al.: Design Patterns, (Addison-Wesley) ▪ Martin Fowler: Refactoring, Engl. ed. (Addison-Wesley Professional) ▪ U. Hammerschall: Verteilte Systeme und Anwendungen (Pearson Studium) ▪ Andreas Andresen: Komponentenbasierte Softwareentwicklung m. MDA, UML2, XML (Hanser Verlag) ▪ T. Ritter et. al.: CORBA Komponenten. Effektives Software-Design u. Progr. (Springer) ▪ Bernd Oestereich: Analyse und Design mit UML 2.5 (Oldenbourg) ▪ OMG Unified Modeling Language Spec., www.omg.org/um ▪ I. Sommerville: Software Engineering (Addison-Wesley / Pearson Studium) ▪ K. Beck: eXtreme Programming (Addison-Wesley Professional) ▪ Ken Schwaber: Agiles Projektmanagement mit Scrum (Microsoft Press)
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ QEKS in Master Communication Systems and Networks PO4 ▪ QEKS in Master Elektrotechnik PO3 ▪ QEKS in Master Elektrotechnik und Informationstechnik PO1 ▪ QEKS in Master Technische Informatik PO3 ▪ QEKS in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	22.10.2025, 11:22:18

6.35 RFSD - RF System Design

Module ID	RFSD
Module Name	RF System Design
Type of Module	Elective Modules
Recognized Course	RFSD - RF System Design
ECTS credits	5
Language	englisch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Rainer Kronberger
Lecturer(s)	Prof. Dr. Rainer Kronberger (Professor Fakultät IME)

Learning Outcome(s)

> In general: Students will learn how high frequency components of wireless communication systems work
> Module-specific:
> students will get a general introduction in rf systems
> they will learn in detail how transmitters and receivers in wireless communication systems work
> they will learn in detail how the components of such systems (LNA, mixer, amplifier, oscillator, etc.) work
> they will learn about limitation effects and noise in such systems
> they will learn how to adapt the components to each other and how to plan and design the complete system (transmitter and / or receiver)

Module Contents

Lecture / Exercises

> RF System, Applications

> Noise in RF systems
> noise classification and characterization
> noise calculation
> noise figure
> noise matching

> Linear and nonlinear circuit behaviour
> theory
> nonlinearities with mixers
> nonlinearities with amplifiers

> RF system components
> receiver componenets
> transmitter components
> frequency generation

Lab

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Lab
Examination Types with Weights	cf. exam regulations
Workload	150 Hours

Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	No formal requirements, but students should have knowledge in High Frequency and Microwave Topics
Mandatory Prerequisites	▪ Participation in final examination only after successful participation in Lecture / Exercises ▪ Lab requires attendance in the amount of: 3 Labortermine und 1 Präsentationstermin ▪ Participation in final examination only after successful participation in Lab
Capacity-limited admission	no
Recommended Literature	▪ Kraus & Carver Eletromagnetics, McGraw Hilll, 2006. ▪ Michale Steer, Microwave and RF Design
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2 ▪ PFM - Profile Module
Included in Specialization	CS - Communication Systems
Use of the Module in Other Study Programs	▪ RFSD in Master Communication Systems and Networks PO4 ▪ RFSD in Master Elektrotechnik und Informationstechnik PO1 ▪ RFSD in Master Medientechnologie PO4 ▪ RFSD in Master Technische Informatik PO3 ▪ RFSD in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.36 RM - Rastermikroskopie

Module ID	RM
Module Name	Rastermikroskopie
Type of Module	Elective Modules
Recognized Course	RM - Scanning Microscopy
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Stefan Altmeyer
Lecturer(s)	Prof. Dr. Stefan Altmeyer (Professor Fakultät IME)

Learning Outcome(s)

Was:
Das Modul vermittelt vertieftes MINT- und studiengangsspezifisches Fachwissen (K5, K6), schult sie Abtraktionsfähigkeit, Analysefähigkeit und sowie die Fähigkeit zur Bewertung komplexes Systeme (K7, K8, K9).

Vorlesungsbegleitend findet ein projektnahes Praktikum statt. Situations- und sachgerechtes argumentieren (K12) wird durch die Prakitkumsgespräche geübt. Die eigenständige Bearbeitung komplexer wissenschaftlicher Aufgaben (K10) und die Projektorganisation (K13) wird ebenso trainiert

Womit:
Der Dozent vermittelt das vertieftem MINT- und einschlägigem Fachwissen in einer Vorlesung mit integrierten kurzen Übungsteilen und einem dedizierten Freiraum für fachliche Diskussionen, um Sprachgebrauch und Ausdrucksfähigkeit zu schulen und auf den wissenschaftlichen Diskurs vorzubereiten.

Weiterhin wird das Praktikum gezielt projektartig durchgeführt und wird wie ein kleiner Forschungsauftrag verstanden. Die Praktikumsaufgaben sind in Ihrer Fragestellung zunächst weit gefasst sind, müssen von den Studierenden selber konkretisiert werden und können dann mit einer weit reichenden zeitlichen Flexibilität abgearbeitet werden. Dazu erhalten die Studierenden zu jeder Zeit der Laboröffnungszeiten Zugang zu der Geräteausstattung. Begleitet wird das Praktikum von regelmäßigen, wissenschaftlichen Diskussionen.

Wozu:
Vorbereitung auf eine selbständige, forschende Tätigkeit, sowohl fachlich als auch organsiatorisch. (HF1)
Anwendung tiefgreifende Fachkenntnisse im Bereich höchstauflösender Mess- und Analyseverfahren, die industriell als Mess- und Prüftechnologie zur Qualitätskontrolle von Produkten (HF2) eingesetzt werden, sowie Kompetenzvermittlung im Bereich der Überwachung von Produktionsprozessen (HF3)

Module Contents

Lecture / Exercises

electron microscopy
wave-particle dualism of electrons, De Brogli wavelength
reletivistic mass increas
resolution of electron optical systems
depth of field in an electron microscope
electron emission
physics of electron emission
thermoionic emission
Schottky emission
field emission
technical construction of electron emitters
brigthness as a conserving magnitude
magentic deflection units
focussing lens
equations of motion for electrons in focussing lenses
principles of aberration minimization
scan system
electron matter interaction
primary electrons
secondary electrons
Auger electrons
Bremsstrahlung
characteristic x rays
cathodo luminescence
Everhart-Thornley detector
electron contrast
topography contrast
material contrast
lattice orientation contrast
conductivity contrast
applications and limitations

tunneling microscope
wave function
definition
continuity and continuous differentiable
probability interpretation
principle
potential diagram
Fermi level
work function
quantummechanical calculation of the tunneling probability
biased tunneling barrier and WKB approximation
piezo motors
physical principles
nonlinearity, hysteresis, creep
principles of control theory in a tunneling microscope
preparation of tunneling tips
image as result of a measurement
convolution of object and tip
lattive resolution and atomic resolution
applications and limits

atomic force microscope
setup

types: contact mode, noncontact mode, tapping mode, magnetic mode,
applications and limits

confocal microscopy
principle of confocal apertures
principle of optical sectioning
lateral and axial resolution
pupil illumination and over-illumination in concofal laser scanning microscopes
problems of adjustment
Nipkow disc
freedom of adjustment
light budget and reflections
rotating microlens array
confocal dispersion sensor
applications and limits

electron micorscope
calculate classical and relativistic electron speeds
calculate wavelngths of electron
calculate resolution of electron optical systems
explain the different emission regimes
explain the different electron-matter interaction processes
sketch and explain the different types of electron lenses
sketch and explain an Everhart-Thornley detector
calculate the depth of field in an electron microscope

tunneling microscope
sketch and explain the potential over space diagram for tunneling
explain the Ansatz to calculate the tunneling probability
explain the difference between atomic- and lattice resolution

Lab

Adjustment and use of
electron microscopes
tunneling microscopes
atomic force microscopes
confocal micorscopes

perform a metrological task
measurement of hights
measurement of 3D topographies
structural analysis
finding ultimate resolution limits

interpretation of metrological findings

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Lab
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours

Recommended Prerequisites	mathematics: differential- and integral calculus complex numbers vector calculus basics of differential geometry physics / optics: geometrical optics wave optics
Mandatory Prerequisites	▪ Lab requires attendance in the amount of: 5 Labortermine ▪ Participation in final examination only after successful participation in Lab
Capacity-limited admission	no
Recommended Literature	▪ Reimer: Scanning Electron Microscopy (Springer) ▪ Meyer, Hug, Bennewitz: Scanning Probe Microscopy (Springer) ▪ Wilhelm, Gröbler, Gluch, Heinz: Die konfokale Laser Scanning Mikroskopie (Carl Zeiss)
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ RM in Master Communication Systems and Networks PO4 ▪ RM in Master Elektrotechnik PO3 ▪ RM in Master Elektrotechnik und Informationstechnik PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.37 RP - Research Project

Module ID	RP
Module Name	Research Project
Type of Module	Mandatory Module
Recognized Course	RP - Research Project at MaCSN
ECTS credits	10
Language	englisch
Duration of Module	1 Semester
Recommended Semester	2
Frequency of Course	every term
Module Coordinator	Studiengangsleiter(in) Master CSN (undefined)
Lecturer(s)	

Learning Outcome(s)

> Studierende untersuchen und lösen eine wissenschaftliche Problemstellung,
> indem sie
> - selbständig den aktuellen Stand der Wissenschaft auf einem Fachgebiet durch Literaturrecherche erarbeiten,
> - ein eigenes Projekt in Abstimmung mit Kollegen planen, durchführen und kontrollieren,
> - das gegebene Problem selbständig (oder im Team) mit wissenschaftlichen Methoden untersuchen und lösen,
> - im Studium erworbenes Fachwissen auf Problemstellung anwenden und hierbei vertiefen,
> - eigene Lösung mit alternativen Lösungsmöglichkeiten vergleichen,
> - erstellte Lösung in Gesamtzusammenhang einordnen und aus fachlicher und gesellschaftlicher Sicht kritisch bewerten und
> - den Stand der Wissenschaft, die fachlichen Grundlagen, die gewählte Lösung und ihre Bewertung gegenüber den weiteren möglichen Lösungsalternativen klar und nachvollziehbar in schriftlicher Form darstellen, um wissenschaftliche Methoden in folgenden Modulen, insbesondere der Masterarbeit, und späteren Berufsleben anwenden zu können.

Module Contents

Research Project

> As part of the project, the student should work individually on a research topic, analyze a problem in a scientific way, find new or suitable ways to solve the problem, plan the project in a scientific way, conduct experiments, simulations and/or theoretical work, evaluate the results, present the results and write a report.

Teaching and Learning Methods	Research Project
Examination Types with Weights	cf. exam regulations
Workload	300 Hours
Contact Hours	12 Hours ≙ 1 SWS
Self-Study	288 Hours
Recommended Prerequisites	
Mandatory Prerequisites	Participation in final examination only after successful participation in Research Project
Capacity-limited admission	no

Recommended Literature	
Included in Elective Catalog	
Included in Specialization	
Use of the Module in Other Study Programs	RP in Master Communication Systems and Networks PO4
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.38 SIM (FEM) - Simulation in der Ingenieurswissenschaft

Module ID	SIM
Module Name	Simulation in der Ingenieurswissenschaft
Type of Module	Elective Modules
Recognized Course	FEM - Finite element method in electrical engineering
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Wolfgang Evers
Lecturer(s)	Prof. Dr. Wolfgang Evers (Professor Fakultät IME)

Learning Outcome(s)

> Die Studierenden können technische Systeme mit Hilfe von rechnergestützten, numerischen Simulationen berechnen,
> indem sie Modelle der realen Systeme bilden, diese als Modelle in einem Simualtionsprogramm erstellen und unter den gewünschten Randbedingungen die Berechnungen durchführen und auswerten
> um später bei Entwicklungsaufgaben das Verhalten von zu entwickelnden Produkten im Voraus bestimmen und optimieren können.

Module Contents

Lecture / Exercises

> Discretisation of physical problems using the example of an electrostatic arrangement
> - One-dimensional model
> - Two-dimensional model
> - Replacement of partial derivatives by finite differences
> - Boundary conditions
> - Setting up the linear system of equations
> - Different methods for solving the system of equations
> - Result representation with interpolation
> - Use of boundary-fitted grids
> - Solving a two-dimensional electrostatic problem with FEM software
> - Exploiting symmetries in the simulation
> - Solving a two-dimensional magnetic problem with FEM software
> - Extending the magnetic problem to include non-linear material properties
> - Extension of the simulation by program-controlled variation of parameters and automatic output of characteristic diagrams with Python

> Carry out and critically evaluate FEM simulations on various physical effects

Project

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Project
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours

Recommended Prerequisites	- Electrostatic: field strength, flux density, dielectrics - Electromagnetism: field strength, flux density, flux, magnetic circuits, induced voltage
Mandatory Prerequisites	
Capacity-limited admission	no
Recommended Literature	▪ Thomas Westermann, Modellbildung und Simulation ▪ Thomas Westermann: Mathematik für Ingenieure
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ SIM in Master Communication Systems and Networks PO4 ▪ SIM in Master Elektrotechnik PO3 ▪ SIM in Master Elektrotechnik und Informationstechnik PO1 ▪ SIM in Master Technische Informatik PO3 ▪ SIM in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
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6.39 SNEE - Stromnetze für erneuerbare Energien

Module ID	SNEE
Module Name	Stromnetze für erneuerbare Energien
Type of Module	Elective Modules
Recognized Course	SNEE - Electrical Power Grids for Renweable Energy
ECTS credits	5
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Eberhard Waffenschmidt
Lecturer(s)	Prof. Dr. Eberhard Waffenschmidt (Professor Fakultät IME)

Learning Outcome(s)

> Vor dem Hintergrund einer klima- und ressourcenschonenden Energiewende stehen unsere Stromnetze vor einem fundamentalen Wandel, der sich in den Zielen dieses Moduls wiederspiegelt.
> WAS: Die Studierenden erkennen die größten Herausforderungen an die elektrischen Verteilnetze und erarbeiten und bewerten Lösungsvorschläge.
> WOMIT: Sie benennen die verschiedenen Netzformen, Komponenten und verwenden Fachbegriffe der elektrischen Netze. Sie berücksichtigen ihre Kenntnis der relevanten technischen und rechtlichen Vorgaben beim Anschluss von dezentralen Einspeisern an das Stromnetz. Sie kennen die verschiedenen Berechnungs-Methoden zur Analyse von elektrischen Netzen und wenden anwendungsbezogen die passende Methode an. Sie berücksichtigen die Grundlagen zur Steuerung und Regelung von elektrischen Netzen beim Einsatz von reglungstechnischen Berechnungsmethoden.
> Aufbauend auf diesen Kompetenzen erstellen sie in Arbeitsgruppen Simulationsmodelle von elektrischen Netzen. Sie analysieren die Simulationsergebnisse anhand von vermittelten Rahmenbedingungen und bewerten die Ergebnisse anhand der selbst vorgegeben Ziele.
> WOZU: Sie können später beurteilen, ob Stromnetze eines Netzbetreibers den zukünftigen Anforderungen genügen und sind in der Lage, einen sachgerechten Ausbau zu planen. Ferner können sie beurteilen, ob oder unter welchen Umständen ein Netzanschluss von dezentralen Einspeisern oder größeren Lasten möglich ist.

Module Contents

Lecture

- The students name different grid topologies, components and are able to use terms related to electrical power grids.
- They consider their knowledge of relevant technical and legal requirements for the connection of decentralized generators to the power grid.
- They know different calculation methods for the analysis of electerical power grids and apply the suitable methode for a particular problem.
- They consider the basiccs for the control of electrical power grids using suitable control methods.
- Summarizing it includes the following topics:
- Grid topologies and components
- Calculation and simulation of power grid
- Fault management
- Grid control
- Gridconnection of decentralized generators

Based on these competencies the students perform project works (see "Projektarbeit").

Project

Based on the knowledge of the lectures the students perform a project. They create simulation models of electrical power grids working in teams of 3 to 4 persons. They analyze the simulation results according to frame conditions and evaluate the results along self generated goals.
Project topics are:
Future loads of electrical power grids due to
- Photovoltaics
- Electromobility
- Electrical heat usage
- Electrical heat storages

under different requirements as e.g. settlement areas
- city
- suburban
- rural

The project work is performed during the presence time with moderation of the lecturer and as homework.

Teaching and Learning Methods	▪ Lecture ▪ Project
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	34 Hours ≙ 3 SWS
Self-Study	116 Hours
Recommended Prerequisites	Basics of electrical Engineering, especially alternating current calculations with complex numbers and three phase systems
Mandatory Prerequisites	
Capacity-limited admission	no

Recommended Literature	▪ Klaus Heuck, Klaus-Dieter Dettmann, Detlef Schulz, "Elektrische Energieversorgung", 7. vollständig überarbeitete und erweiterte Auflage, Vieweg Verlag, Wiebaden, 2007. ISBN 978-3-8348-0217-0 ▪ Dieter Nelles, Christian Tuttas,"Elektrische Energietechnik", B.G. Teubner Verlag, Stuttgart, 1998, ISBN 3-519-06427-8 ▪ Valentin Crastan,"Elektrische Energieversorgung 1: Netzelemente, Modellierung, stationäres Verhalten, Bemessung, Schalt- und Schutztechnik", 2. bearbeitete Auflage, Springer Verlag, Berlin Heidelberg New York, 2007, ISBN 978-3-540-69439-7 ▪ „Erzeugungsanlagen am Niederspannungsnetz – Technische Mindestanforderungen für Anschluss und Parallelbetrieb von Erzeugungsanlagen am Niederspannungsnetz“, VDE-Anwendungsregel VDE-AR-N 4105, Aug. 2011, verbindlich gültig ab 1.1.2012.
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ SNEE in Master Communication Systems and Networks PO4 ▪ SNEE in Master Elektrotechnik PO3 ▪ SNEE in Master Elektrotechnik und Informationstechnik PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.40 SYE - Systemtechnik für Energieeffizienz

Module ID	SYE
Module Name	Systemtechnik für Energieeffizienz
Type of Module	Elective Modules
Recognized Course	SYE - Systems Engineering for Energy Efficiency
ECTS credits	5
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Johanna May
Lecturer(s)	Prof. Dr. Johanna May (Professorin Fakultät IME)

Learning Outcome(s)

> Bestehende und neuartige Systeme und Produkte systematisch auf energetische Optimierungspotenziale hin analysieren und daraus Verbesserungen für die Energieeffizienz ableiten, indem funktionelle Anforderungen in technische Kennzahlen übersetzt werden, messtechnische Verfahren angewandt und eigene sowie Werte aus der Literatur kritisch bewertet werden, starke Einflussparameter ermittelt werden, Kreativitätsmethoden angewendet werden, mit starken Einflüssen Funktionsmodelle simuliert werden und die Sichtweisen verschiedener Stakeholder berücksichtigt werden, um später im Beruf damit neuartige Systeme energieeffizienter konzipieren zu können oder bei bestehenden Systemen Anhaltspunkte zur Verbesserung der Energieeffizienz zu ermitteln.

Module Contents

Lecture / Exercises

> electrical power measurements and thermography (lab), analyse load profiles and simulation in python, use relevant standards for evaluation of energy payback time, economic viability and life cycle analysis, overview over most frequenz energy efficiency measures (pressurized air, lighting, heat recovery)

> translate functional requirements on systems and products into technical key parameters and document knowlegde, apply measurements and critically evaluate own and data from literature, find influencing factors, use creativity methods, simulate strong influence factors in functional models and evaluate potentials for improvement quantitatively, evaluate acceptance from different viewpoints

Lab

> thermography, measurement of electrical energy of more or less energy efficient consumers, measure electrical load profiles (at home), critical evaluation of measurement uncertainty

Project

> apply methods of lecture to a specific (every semester newly conceived) project topic in the area of energy efficiency, work in a team

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Lab ▪ Project
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	57 Hours ≙ 5 SWS
Self-Study	93 Hours

Recommended Prerequisites	Bachelor electrical engineering, renewable energy or comparable
Mandatory Prerequisites	▪ Project requires attendance in the amount of: 5 Projektermine, Präsentation, mündliche Prüfung ▪ Participation in final examination only after successful participation in Project
Capacity-limited admission	yes, according to approved request
Recommended Literature	▪ M. Pehnt: Energieeffizienz: Ein Lehr- und Handbuch, Springer, 1. korrigierter Nachdruck 2010, ISBN 9783642142512 ▪ M. Günther: Energieeffizienz durch Erneuerbare Energien: Möglichkeiten, Potenziale, Systeme, Springer Fachmedien Wiesbaden, 2015, ISBN 9783658067533 ▪ F. Wosnitza, H.G. Hilgers: Energieeffizienz und Energiemanagement: Ein Überblick heutiger Möglichkeiten und Notwendigkeiten, Vieweg + Teubner Verlag, 2012, ISBN 9783834886712 ▪ J. Hesselbach: Energie- und klimaeffiziente Produktion: Grundlagen, Leitlinien und Praxisbeispiele, Vieweg + Teubner Verlag, 2012, ISBN 9781280786358 ▪ Recherche über scopus, Webinare der EU (leonardo)
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ SYE in Master Communication Systems and Networks PO4 ▪ SYE in Master Elektrotechnik PO3 ▪ SYE in Master Elektrotechnik und Informationstechnik PO1
Specifics and Notes	
Last Update	22.10.2025, 11:22:18

6.41 TED - Theoretische Elektrodynamik

Module ID	TED
Module Name	Theoretische Elektrodynamik
Type of Module	Elective Modules
Recognized Course	TED - Theoretical Electro Dynamics
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Holger Weigand
Lecturer(s)	Prof. Dr. Holger Weigand (Professor Fakultät IME)

Learning Outcome(s)

Mikroskopische/differentielle Beschreibung der Elektrodynamik kennenlernen
Bedeutung/Interpretation der mikroskoopisch, differentiellen Maxwell-und Material-Gleichungen kennenlernen
makroskopische aus differentielle Beschreibung ableiten
Potentialentwicklungen zur näherungsweisen Problemlösung anwenden
Analogien zwischen elektrisch und magnetischen Effekten zur Problemlösung kennenlernen

Lösungsansätze zu den Maxwell-Gleichungen kennenlernen und analysieren
elektrotechnischer Effekte aus Maxwellgleichungen ableiten
Potentialtheorien zur Lösung elektrotechnischer Fragestellungen anwenden
Vektoroperatoren und Integralsätze anwenden
3-dim Vektoranalysis und Integralsätze anwenden
Analogien zwischen elektrisch und magnetischen Effekten zur Problemlösung erkennen und nutzen
Kapzitäten und Induktivitäten beliebiger Ladungs- bzw. Stromverteilungen berechnen

Module Contents

Lecture / Exercises

Introduction into Electro Dynamics
Charges, currents
Forces, fields

Classical Electro Dynamics
Electrostatics
Field, potential
Polarization
Electrostatic energy
Capacity
Multi pole development
Interaction of charge distributions
Stationary electrical field
Magnetostatics
Stationary magnetical field
Vector potential
Magnetization
Magetostatic energy
Inductivity
Quasi stationary electromagnetic fields
Induction effects
Skin effect
Rapidly changing electromagetic fields
Electromagnetic wves
Reflection and diffraction

Knowledge of meaning of Maxwell- and material equations

Dervation of electric/magnetic potential/field from charge/current distributions

Development of potential / field to monopole, dipole, quadrupole and higher moments

Caculation of capacity/inductivity to charge/current distributions from energy balance

Derivation of Continuity equation, Kirschhoff Laws from Maxwell equations

Derivation and solving of diffusion/wave equations from Maxwell equations

Solving of macroscopic problems by intergation of microscopic/differential description

Solving of training examples

Teaching and Learning Methods	Lecture / Exercises
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	34 Hours ≙ 3 SWS
Self-Study	116 Hours
Recommended Prerequisites	Vector analysis
Mandatory Prerequisites	
Capacity-limited admission	no
Recommended Literature	▪ Lehner: "Elektromagnetische feldtheorie für Ingenieure", Springer-Verlag ▪ Wunsch: "Elektromagnetische Felder", Verlag technik

Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ TED in Master Communication Systems and Networks PO4 ▪ TED in Master Elektrotechnik PO3 ▪ TED in Master Elektrotechnik und Informationstechnik PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.42 THI - Theoretische Informatik

Module ID	THI
Module Name	Theoretische Informatik
Type of Module	Elective Modules
Recognized Course	THI - Theoretical Computer Science
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Hubert Randerath
Lecturer(s)	Prof. Dr. Hubert Randerath (Professor Fakultät IME)

Learning Outcome(s)

> (WAS) Die Studierenden erlernen formale Grundlagen der Informatik
> (WOMIT) indem Sie
> - den Umgang mit Typ2, Typ1 und Typ0-Sprachen erlernen und formale Maschinen konstruieren, die Sprachen des jeweileigen Typs erkennen,
> - mit formalen Modellen der Informatik arbeiten,
> - Kenntnisse der Berechenbarkeits, Entscheidbarkeits- und Komplexitätstheorie auf praktische Probleme anwenden,
> - einen präzisen Algorithmenbegriff verwenden, um die Tragweite von Algorithmen zu beschreiben und die Komplexität von Algorithmen zu bestimmen,
> - die prinzipielle Lösbarkeit algorithmischer Probleme untersuchen,
> (WOZU) um in Forschungsergebnisse in späteren Lehrveranstaltungen und Abschlussarbeiten auf ein solides theoretisches Fundament stellen zu können.

Module Contents

Lecture / Exercises

> An algorithm's complexity can be determined by analyzing its input and the algorithmic core, e.g., by means of the O-notation. The analysis might consist of a polynomial reduction of a known hard problem like the satisfiability problem in propositional logic of the unknown problem.

Teaching and Learning Methods	Lecture / Exercises
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	34 Hours ≙ 3 SWS
Self-Study	116 Hours
Recommended Prerequisites	Basics in automata theory and formal languages
Mandatory Prerequisites	
Capacity-limited admission	no

Recommended Literature	▪ Theoretische Grundlagen der Informatik, Rolf Socher, Hanser Verlag ▪ Theoretische Informatik, Juraj Hromkovic, Teubner-Verlag ▪ Grundkurs Theoretische Informatik, Gottfried Vossen und Kurt-Ulrich Witt,Vieweg-Verlag ▪ Theoretische Informatik - kurzgefasst, Uwe Schöning, Spektrum Akademischer Verlag
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ THI in Master Communication Systems and Networks PO4 ▪ THI in Master Technische Informatik PO3 ▪ THI in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.43 TSVP - Technologien und Systeme der Videoproduktion

Module ID	TSVP
Module Name	Technologien und Systeme der Videoproduktion
Type of Module	Elective Modules
Recognized Course	TSVP - Technologies and Systems of Video Production
ECTS credits	5
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr.-Ing. Ulrich Reiter
Lecturer(s)	Prof. Dr.-Ing. Ulrich Reiter (Professor Fakultät IME)

Learning Outcome(s)

> WAS: Studierende analysieren aktuelle und zukünftige Produktionstechnologien und Systeme audiovisueller Medien hinsichtlich unterschiedlicher Faktoren wie Anwendbarkeit, Potential, Kosten/Nutzen, etc. in verschiedenen exemplarischen Anwendungsszenarien. Sie lernen, Technologien aus teilweise anderen Anwendungsgebieten mit Hilfe wissenschaftlicher Methoden auf ihre Einsatzmöglichkeit in der Medienproduktion hin zu untersuchen. Die kritische Auseinandersetzung mit der technischen Literatur und die Anwendung der Regeln guten wissenschaftlichen Arbeitens befähigt sie, wissenschaftliche begründete Aussagen zu treffen.
>
> WOMIT: Dazu führen sie in kleinen Teams eine Literaturrecherche sowie evtl. Befragungen und Interviews mit Experten durch, mit Hilfe derer sie die betreffenden Technologien verstehen und eine Einordnung vornehmen können. Zum Abschluss des Projektes fertigen sie einen Bericht an und halten einen Fachvortrag.
>
> WOZU: Studierenden wird ein kritischer Umgang mit neuen Technologien ermöglicht, da sie wissenschaftlich arbeiten können. Sie können komplexe Technologien analysieren, daraus technologische Empfehlungen ableiten und somit fachliche Führungs- und Projektverantwortung übernehmen.

Module Contents

Project

> - mastering of methods of good scientific practice, especially with respect to information retrieval as well as to documentation and presentation of expert knowledge

> - expert knowledge in specific topics from the field of Technologies and Systems for Audiovisual Media Production, as well as from neighboring disciplines that are already or will become potentially relevant for the field of media production technologies

Teaching and Learning Methods	Project
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	12 Hours ≙ 1 SWS
Self-Study	138 Hours
Recommended Prerequisites	- basic knowledge in media production technologies and systems
Mandatory Prerequisites	▪ Project requires attendance in the amount of: 2 Termine ▪ Participation in final examination only after successful participation in Project

Capacity-limited admission	no
Recommended Literature	▪ diverse aktuelle Papers zum jeweiligen Thema
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ TSVP in Master Communication Systems and Networks PO4 ▪ TSVP in Master Medientechnologie PO3 ▪ TSVP in Master Medientechnologie PO4
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.44 VAE - Virtual Acoustic Environments

Module ID	VAE
Module Name	Virtual Acoustic Environments
Type of Module	Elective Modules
Recognized Course	VAE - Virtual Acoustic Environments (VAE)
ECTS credits	5
Language	englisch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr.-Ing. Christoph Pörschmann
Lecturer(s)	Prof. Dr.-Ing. Christoph Pörschmann (Professor Fakultät IME)

Learning Outcome(s)

> What: The students learn the basic concepts , the technology and perception-related aspects of cirtual acoustic environemtns. The course will be strongly related to research aspects and projects
> How: The students apply their knowledge on Signal Processing, Audio, and in the field of VR on different aspects of Virtual Acoustic Environements. Actual trends in reseach and state of the art applications will integrated, tested, analyzed and evaluated.
> Aim: The students shall be able to work on research topics which consider topics whic are scientifically new and relevant. Apects of scalability and commercialization play a role

Module Contents

Lecture

> The basic concepts of headphone-based or loudspeaker-based VR-systems are introduced

Project

> In one specific topic of Virtual Acoustic Environments the students shall get deep know-how on the technology and apply it to a practical problem and present the results

Lab

Teaching and Learning Methods	▪ Lecture ▪ Project ▪ Lab
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	Know-how on Acoustics and audio signal processing
Mandatory Prerequisites	
Capacity-limited admission	no

Recommended Literature	▪ Rozinska, A. "Immersive Sound" ▪ Blauert, J. "Spatial Hearing" ▪ Zotter, F., Frank, M. "Ambisonics: A Practical 3D Audio Theory for Recording, Studio Production, Sound Reinforcement, and Virtual Reality"
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2 ▪ PFM - Profile Module
Included in Specialization	CS - Communication Systems
Use of the Module in Other Study Programs	▪ VAE in Master Communication Systems and Networks PO4 ▪ VAE in Master Elektrotechnik und Informationstechnik PO1 ▪ VAE in Master Medientechnologie PO3 ▪ VAE in Master Medientechnologie PO4 ▪ VAE in Master Technische Informatik PO3 ▪ VAE in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
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6.45 VER - Virtuelle und erweiterte Realität

Module ID	VER
Module Name	Virtuelle und erweiterte Realität
Type of Module	Elective Modules
Recognized Course	VER - Virtual and Augmented Reality
ECTS credits	5
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr.-Ing. Arnulph Fuhrmann
Lecturer(s)	▪ Prof. Dr.-Ing. Arnulph Fuhrmann (Professor Fakultät IME) ▪ Prof. Dr. Stefan Grünvogel (Professor Fakultät IME)

Learning Outcome(s)

WAS:
Das Modul vermittelt folgende Kenntnisse und Fertigkeiten:
- Virtual- und Augmented-Reality-Anwendungen konzipieren, aufbauen und bewerten
- Interaktions und Navigationsverfahren erstellen
- Basistechnologien der virtuellen und erweiterten Reality weiterentwickeln
- Werkzeuge und Methoden zur Entwirklickung von VR/AR-Anwendungen verwenden
- Algorithmische und mathematische Grundlagen von VR/AR anwenden

WOMIT:
Die Kompetenzen werden zunächst über eine Vorlesung durch die Dozenten vermittelt und danach im Praktikum anhand konkreter Aufgabenstellung von den Studierenden vertieft. Im seminaristischen Teil der Lehrveranstaltung recherieren die Studierenden zu vorgegebenen Themen anhand von Fachartikeln und weiteren Informationsquellen über neue Konzepte der virtuellen und erweiterten Realität und stelle diese dar in einer Präsentation dar.

WOZU:
Die sichere Anwendung der Grundlagen der virtuellen und erweiterten Realität ist Voraussetzung für die Entwicklug komplexer interaktiver medientechnischer Systeme (HF1). Weiterhin erlaubt das Grundlagenwissen die Bewertung bestehender Systeme und das wissenschaftliche Arbeiten in diesem Gebiet (HF2).

Module Contents

Lecture

Explain terms from the field of virtual and augmented reality
Explain and compare data structures and algorithms for VR/AR applications
3D data formats
Spatial data structures
Describing Multimodal User Interfaces
Selection of 3D objects
Manipulation of 3D objects
Navigation in virtual scenes
system control
Describe input and output devices and specific virtual and augmented reality hardware
display technologies
Stereo Displays
Autostereoscopic Displays
projection solutions
Wearable Displays
Head Mounted Displays
Handheld Displays
See-through Displays
Workbench
Cave
Tiled Displays
3D-Audio
Force Feedback Devices
Haptic feedback
input devices
controller
data gloves
locomotion devices
Explain algorithmic and mathematical basics
stereoscopy
tracking
capture of position and orientation: Degrees of freedom
tracking technologies
Mechanical
Optical
Electromagnetic
ultrasound
interial
eye tracking
head tracking
object tracking
Markerless Tracking
Marker-Based Tracking
rendering
management of large 3D scenes
haptic rendering
stereo rendering
real-time rendering
collision detection
intersections between primitives
Discrete and continuous collision detection
acceleration data structures
collision response

Lab

- Design, build and evaluate virtual environments and augmented reality applications
- Creating Interaction and Navigation Procedures
- Further develop fundamental technologies of virtual and augmented reality
- Use tools and methods to implement VR/AR applications
- Apply algorithmic and mathematical principles of VR/AR
- understand and grasp textual tasks
- Testing and debugging your own application

Seminar

Apply Algorithmic and Mathematical fundamentals
Check interaction and navigation procedures
Independently obtaining and summarizing scientific literature
Present and discuss new concepts of virtual and augmented reality

Teaching and Learning Methods	▪ Lecture ▪ Lab ▪ Seminar
Examination Types with Weights	cf. exam regulations
Workload	150 Hours
Contact Hours	45 Hours ≙ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	Computer Graphics Computer Animation
Mandatory Prerequisites	Lab requires attendance in the amount of: 2 Termine
Capacity-limited admission	no
Recommended Literature	▪ R. Dörner et al., Virtual und Augmented Reality (VR/AR): Grundlagen und Methoden der Virtuellen und Augmentierten Realität, Springer Vieweg, 2019 ▪ Schmalstieg und Höllerer, Augmented Reality – Principles and Practice, Addison Wesley, 2016 ▪ T. Akenine-Möller, et al., Real-Time Rendering Fourth Edition, Taylor & Francis Ltd., 2018 ▪ J. Jerald, The VR Book: Human-Centered Design for Virtual Reality, Acm Books, 2015
Included in Elective Catalog	▪ EL1 - Electives Catalog 1 ▪ EL2 - Electives Catalog 2
Included in Specialization	
Use of the Module in Other Study Programs	▪ VER in Master Communication Systems and Networks PO4 ▪ VER in Master Medientechnologie PO3 ▪ VER in Master Medientechnologie PO4 ▪ VER in Master Technische Informatik PO3 ▪ VER in Master Informatik und Systems-Engineering PO1
Specifics and Notes	
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7. Electives Catalogs

The following shows which modules can be selected in a particular elective area. The following notes and regulations apply to all elective areas:

- **When choosing modules from elective catalogs, the conditions formulated in Specializations also apply.**
- The semester in which elective modules of an elective catalog can typically be taken can be found in the study plans.
- As a rule, modules are only offered in either the summer or winter semester. This means that any required accompanying examination can only be taken in this semester. The summative examinations for modules in Faculty 07 are usually offered in the examination period after each semester.
- A completed module is recognized for a maximum of one elective area, even if it is listed in several elective areas.
- There is an admission restriction for some modules. More information on this can be found in the announcements on admission restrictions.
- Registration and admission to non-faculty modules are subject to deadlines and other conditions set by the faculty or university offering the module. Their admission cannot be guaranteed. Students must contact the relevant external lecturer in good time to find out whether they are allowed to take part in an external module and what they need to do to register and participate.
- Upon application, a suitable modules can be added to the elective area. Such an application must be submitted informally to the head of degree program at least four months before the planned participation in that module. The examination board decides on the acceptance of the application in consultation with the head of degree program and suitable teaching staff. A study achievement to be recognized
  - must fit in with the intended graduate profile of the degree program and contribute to its achievement,
  - must be oriented towards learning outcomes and must not serve solely to impart knowledge,
  - must correspond to the qualification level of a Master's degree program,
  - must represent a meaningful increase in competence against the background of the intended course of study,
  - must have been completed by an examination and
  - must not be identical in terms of content and learning outcomes to coursework that has already been completed.
- Modules are not listed below,
  - which in the past were only recognized for an elective catalog as part of individual recognition procedures or
  - which in the past were only recognized for an elective catalog as part of a stay abroad and the associated individual learning agreement.
- Information on calculating interim grades and study progress in connection with elective catalogs can be found in the Examination Office's Merkblatt Leistungspunkte-Berechnung im Wahlbereich der Studiengänge.

Stays abroad

- Students who have integrated a stay abroad into their studies and have completed coursework at a foreign university can have this recognized upon application and with the approval of the examination board.
- A Learning Agreement must be concluded with the Faculty's Recognition Officer before the start of the stay abroad. In particular, it is agreed for which mandatory modules or elective catalogs the coursework completed abroad will be recognized.

7.1 EL1 - Electives Catalog 1

In this elective catalog, master's modules with **technical content** can be freely chosen from the range offered by Faculty 07 at TH Köln and the **Department of Computer Science** at Bonn-Rhein-Sieg University of Applied Sciences. Please note that not every module is offered every year.

You must select modules of 10 ECTS credit points in total out of this catalog.

This elective catalog particularly includes all modules from the following areas:

- Electives Catalog PFM - Profile Module

Modules from these other areas are printed normally in the following, original modules from this elective catalog are printed in bold.

Modules of the faculty

Module ID	Module Name	Rotation	ECTS		
ACC	Advanced Channel Coding	S	5	CS	
AMC	Advanced Multimedia Communications	W	5	CS	N_S
AMS	**Special Aspects of Mobile Autonomous Systems**	W	5		

Module ID	Module Name	Rotation	ECTS		
ARP	**Alternative Rechnerarchitekturen und Programmiersprachen**	W	5		
AVT	**Audio- und Videotechnologien**	W	5		
AVV	**Algorithmen der Videosignalverarbeitung**	W	5		
CI	**Computational Intelligence**	W	5		
CSO	**Computersimulation in der Optik**	W	5		
DBT	**Digitale Bildtechnik**	W	5		
DLO	**Deep Learning und Objekterkennung**	S	5		
DMC	**Digital Motion Control**	S	5		
DSP	Digital Signal Processing	W	5	CS	
EBA	**Elektrische Bahnen**	W	5		
EMM	**Energiemanagement in Energieverbundsystemen**	W	5		
HSUT	**Hochspannungsübertragungstechnik**	S	5		
IBD	**InnoBioDiv**	S+W	5		
IIS	**Intelligent Information Systems**	S	5		
KOGA	**Kombinatorische Optimierung und Graphenalgorithmen**	W	5		
KRY	Cryptography	S	5	CS	N_S
LCSS	**Large and Cloud-based Software-Systems**	S	5		
LSPW	**Leistungselektronische Stellglieder für PV- und Windkraftanlagen**	W	5		
MCI	**Mensch-Computer-Interaktion**	S	5		
MLWR	Maschinelles Lernen und wissenschaftliches Rechnen	S	5	CS	
NGN	Next Generation Networks	S	5	CS	N_S
NLO	**Nichtlineare Optik**	S	5		
OSA	**Optische Spektroskopie und Anwendungen**	S	5		
PAP	**Parallele Programmierung**	S	5		
QEKS (SEKM)	**Qualitätsgesteuerter Entwurf komplexer Softwaresysteme**	W	5		
RFSD	RF System Design	W	5	CS	
RM	**Rastermikroskopie**	W	5		
SIM (FEM)	**Simulation in der Ingenieurswissenschaft**	S	5		
SNEE	**Stromnetze für erneuerbare Energien**	S	5		
SYE	**Systemtechnik für Energieeffizienz**	W	5		
TED	**Theoretische Elektrodynamik**	S	5		
THI	**Theoretische Informatik**	S	5		

Module ID	Module Name	Rotation	ECTS	
TSVP	**Technologien und Systeme der Videoproduktion**	S	5	
VAE	Virtual Acoustic Environments	S	5	CS
VER	**Virtuelle und erweiterte Realität**	W	5	

Modules of other faculties or universities

Affiliation	Module Name	ECTS	
Universidad Politécnica de Madrid	Distributed Systems for IoT	5	N_S
Hochschule Bonn-Rhein-Sieg	Kommunikation in verteilten Systemen	6	N_S

7.2 EL2 - Electives Catalog 2

In this elective catalog, master's modules from the range offered by Faculty 07 at TH Köln and Bonn-Rhein-Sieg University of Applied Sciences can be freely selected. Please note that not every module is offered every year.
You must select modules of 5 ECTS credit points in total out of this catalog.

This elective catalog particularly includes all modules from the following areas:

- Electives Catalog EL1 - Electives Catalog 1

Modules from these other areas are printed normally in the following, original modules from this elective catalog are printed in bold.

Modules of the faculty

Module ID	Module Name	Rotation	ECTS		
ACC	Advanced Channel Coding	S	5	CS	
AMC	Advanced Multimedia Communications	W	5	CS	N_S
AMS	Special Aspects of Mobile Autonomous Systems	W	5		
ARP	Alternative Rechnerarchitekturen und Programmiersprachen	W	5		
AVT	Audio- und Videotechnologien	W	5		
AVV	Algorithmen der Videosignalverarbeitung	W	5		
CI	Computational Intelligence	W	5		
CSO	Computersimulation in der Optik	W	5		
DBT	Digitale Bildtechnik	W	5		
DLO	Deep Learning und Objekterkennung	S	5		
DMC	Digital Motion Control	S	5		
DSP	Digital Signal Processing	W	5	CS	
EBA	Elektrische Bahnen	W	5		
EMM	Energiemanagement in Energieverbundsystemen	W	5		
HSUT	Hochspannungsübertragungstechnik	S	5		
IBD	InnoBioDiv	S+W	5		
IIS	Intelligent Information Systems	S	5		
KOGA	Kombinatorische Optimierung und Graphenalgorithmen	W	5		
KRY	Cryptography	S	5	CS	N_S
LCSS	Large and Cloud-based Software-Systems	S	5		
LSPW	Leistungselektronische Stellglieder für PV- und Windkraftanlagen	W	5		
MCI	Mensch-Computer-Interaktion	S	5		
MLWR	Maschinelles Lernen und wissenschaftliches Rechnen	S	5	CS	
NGN	Next Generation Networks	S	5	CS	N_S
NLO	Nichtlineare Optik	S	5		

Module ID	Module Name	Rotation	ECTS	
OSA	Optische Spektroskopie und Anwendungen	S	5	
PAP	Parallele Programmierung	S	5	
QEKS (SEKM)	Qualitätsgesteuerter Entwurf komplexer Softwaresysteme	W	5	
RFSD	RF System Design	W	5	CS
RM	Rastermikroskopie	W	5	
SIM (FEM)	Simulation in der Ingenieurswissenschaft	S	5	
SNEE	Stromnetze für erneuerbare Energien	S	5	
SYE	Systemtechnik für Energieeffizienz	W	5	
TED	Theoretische Elektrodynamik	S	5	
THI	Theoretische Informatik	S	5	
TSVP	Technologien und Systeme der Videoproduktion	S	5	
VAE	Virtual Acoustic Environments	S	5	CS
VER	Virtuelle und erweiterte Realität	W	5	

Modules of other faculties or universities

Affiliation	Module Name	ECTS	
Universidad Politécnica de Madrid	Distributed Systems for IoT	5	N_S
Hochschule Bonn-Rhein-Sieg	Kommunikation in verteilten Systemen	6	N_S

7.3 EL3 - Elective 3

Für dieses Wahlmodul können beliebige Master-Module aus dem Angebot der TH Köln und der Hochschule Bonn-Rhein-Sieg nach Angebot frei gewählt werden. Erfragen Sie jedoch, welche Voraussetzungen der Lehrende für den Besuch des Moduls erwartet. Diese müssen erfüllt sein, um das Modul besuchen zu können Weitere Module können nur nach vorhergehender Absprache mit der Studiengangsleitung gewählt werden. Bitte beachten Sie bei Ihrer Planung auch, dass die Lehrveranstaltungen in der Regel nur im Sommer- oder Wintersemester angeboten werden. Beachten Sie auch, dass nicht alle Module jedes Jahr angeboten werden.
You must select modules of 5 ECTS credit points in total out of this catalog.

Modules of other faculties or universities

Affiliation	Module Name	ECTS
TH Köln - Fakultät 12	**Statistics**	**5**
TH Köln - Fakultät 12	**Wind Energy**	**5**

7.4 PFM - Profile Module

This elective catalog lists the modules that are assigned to one of the focus areas.
You must select modules of 20 ECTS credit points in total out of this catalog.

This elective catalog particularly includes all modules from the following areas:

- Specialization CS - Communication Systems
- Specialization N_S - Networks & Security

Modules from these other areas are printed normally in the following, original modules from this elective catalog are printed in bold.

Modules of the faculty

Module ID	Module Name	Rotation	ECTS		
ACC	Advanced Channel Coding	S	5	CS	
AMC	Advanced Multimedia Communications	W	5	CS	N_S
DSP	Digital Signal Processing	W	5	CS	
KRY	Cryptography	S	5	CS	N_S
MLWR	Maschinelles Lernen und wissenschaftliches Rechnen	S	5	CS	
NGN	Next Generation Networks	S	5	CS	N_S
RFSD	RF System Design	W	5	CS	
VAE	Virtual Acoustic Environments	S	5	CS	

Modules of other faculties or universities

Affiliation	Module Name	ECTS	
Universidad Politécnica de Madrid	Distributed Systems for IoT	5	N_S
Hochschule Bonn-Rhein-Sieg	Kommunikation in verteilten Systemen	6	N_S

8. Specializations

The following section describes the specializations defined in this degree program (see also §24 of the examination regulations). The following information and regulations apply to all specializations:

- A specialization is deemed to have been successfully completed if modules listed therein amounting to at least 20 ECTS have been successfully completed.
- The completed specializations are listed in a separate annex to the degree certificate.
- Upon application, further suitable modules can be added to a specialization. Such an application must be submitted informally to the head of degree program at least six months before the planned participation in a module to be supplemented. The examination board decides on the acceptance of the application in consultation with the head of degree program and suitable teaching staff.

8.1 CS - Communication Systems

Kommunikationssysteme und deren Funktionalität Absolventen können kommunikationstechnische Systeme entwerfen, aufbauen, erweitern und entwickeln. Sie verfügen über HW und SW Kenntnisse und finden Arbeitsplätze in F&E Bereichen der IKT sowie als Allrounder in allen Bereichen der Industrie und Wirtschaft. Die weiter fortschreitende totale Vernetzung der Dinge (Internet of Things) und die Digitalisierung der Produktion eröffnen langfristig Berufsmöglichkeiten für Absolventen des Studiengangs. Absolventen des Communication Systems Profils arbeiten hier im Speziellen zum Entwurf von Hardware, Firmware und Aufbau von funkbasierten Sensornetzen.

Modules of the faculty

Abbr.	Module Name	Rotation	ECTS
ACC	Advanced Channel Coding	S	5
AMC	Advanced Multimedia Communications	W	5
DSP	Digital Signal Processing	W	5
KRY	Cryptography	S	5
MLWR	Maschinelles Lernen und wissenschaftliches Rechnen	S	5
NGN	Next Generation Networks	S	5
RFSD	RF System Design	W	5
VAE	Virtual Acoustic Environments	S	5

8.2 N_S - Networks & Security

Vernetzung und Sicherheit von Netzwerken und Komponenten. Absolventen dieses Profils finden Ihre beruflichen Herausforderungen im Bereich der Vernetzung von Geräten und Dingen (IoT, Industrie 4.0) und der informationstechnischen Sicherheit . Alle Branchen der Industrie, die Wirtschaft und die öffentliche Verwaltung benötigen heute Experten aus diesen Gebieten. Dabei übersteigt die Nachfrage das Angebot.

Modules of the faculty

Abbr.	Module Name	Rotation	ECTS
AMC	Advanced Multimedia Communications	W	5
KRY	Cryptography	S	5
NGN	Next Generation Networks	S	5

Modules of other faculties or universities

Affiliation	Module Name	ECTS
Universidad Politécnica de Madrid	Distributed Systems for IoT	5
Hochschule Bonn-Rhein-Sieg	Kommunikation in verteilten Systemen	6

9. Examination Types

The forms of examination referenced in the module descriptions are explained in more detail below. The explanations are taken from the examination regulations, §19ff. In case of deviations, the text of the examination regulations applies.

(Digital) Written exam

Written, paper-based or digitally supported examination. Details are regulated in §19 of the examination regulations.

Oral examination

Examination to be taken orally. Details are regulated in §21 of the examination regulations.

Oral contribution

See §22, para. 5 of the examination regulations: An oral contribution (e.g. paper, presentation, negotiation, moderation) serves to determine whether students are capable of independently working on a practice-oriented task within a specified period of time using scientific and practical methods and presenting it in a technically appropriate manner by means of verbal communication. This also includes answering questions from the auditorium regarding the oral presentation. The duration of the oral presentation is determined by the examiner at the beginning of the semester. The facts relevant to the grading of the oral presentation are to be recorded in a protocol; students should also submit the written documents relating to the oral presentation for documentation purposes. Students must be notified of the grade no later than one week after the oral presentation.

Technical discussion

See §22, Para. 8 of the examination regulations: A technical discussion serves to determine professional competence, understanding of complex technical contexts and the ability to solve problems analytically. Students and examiners have roughly equal speaking time in the technical discussion in order to enable a discursive technical exchange. One or more discussions are held with an examiner during the semester or in summary form. Students should present and explain practice-related technical tasks, problems or project plans from the degree program and explain the relevant technical background, theoretical concepts and methodological approaches for processing the tasks. Possible solutions, procedures and considerations for solving the problem must be discussed and justified. The facts relevant to the grading of the technical discussion must be recorded in a protocol.

Project work

See §22, Para. 6 of the examination regulations: The project work is an examination that consists of independently working on a specific problem under supervision using scientific methodology and documenting the results. In addition to the quality of the answer to the question, the organizational and communicative quality of the implementation, such as slides, presentations, milestones, project plans, meeting minutes, etc., are also relevant for assessment.

Lab report

See §22, para. 10 of the examination regulations: An internship report (e.g. experimental protocol) serves to determine whether students are capable of independently carrying out a practical laboratory task within a specified period of time, as well as documenting, evaluating and reflecting on the process and results in writing. Preparatory homework may be required before the actual experiment is carried out. Technical discussions may take place during or after the experiment. Internship reports can also be admitted to the examination in the form of group work. Students must be notified of the assessment of the practical placement report no later than six weeks after submission of the report.

Exercise lab

See §22, para. 11 of the examination regulations: The examination form “practical training” tests the technical skills in the application of the theories and concepts learned in the lecture as well as practical skills, for example the use of development tools and technologies. For this purpose, several tasks are set during the semester, which are to be solved either alone or in group work, on site or as homework by a given deadline. The solutions to the tasks must be submitted by the students in (digital) written form. The exact criteria for passing the examination will be announced at the beginning of the corresponding course.

Exercise lab under examination conditions

See §22, para. 11, sentence 5 of the examination regulations: A “practical training course under examination conditions” is a practical training course in which the tasks are to be completed within the time frame and under the independent conditions of an examination.

Term paper

See §22, para. 3 of the examination regulations: A term paper (e.g. case study, research) serves to determine whether students are capable of independently completing a specialist task in written or electronic form using scientific and practical methods within a specified period of time. The topic and scope (e.g. number of pages of the text section) of the term paper are determined by the examiner at the beginning of the semester. A declaration of independence must be signed and submitted by the candidate. In addition, technical discussions may be held.

Learning portfolio

A learning portfolio documents the student competence development process by means of presentations, essays, excerpts from internship reports, tables of contents of term papers, notes, to-do lists, research reports and other performance presentations and learning productions, summarized as so-called “artefacts”. The learning portfolio only becomes an examination item in conjunction with the student's reflection (in writing, orally or in a video) on the use of these artifacts to achieve the learning objective previously made transparent by the examiner. During the creation of the learning portfolio, feedback on development steps and/or artifacts is given over the course of the semester. A revised form of the learning portfolio - in handwritten or electronic form - is submitted as the examination result following the feedback.

Single / Multiple choice

See §20 of the examination regulations.

Access colloquium

See §22, para. 12 of the examination regulations: An entrance colloquium serves to determine whether the students fulfill the specific requirements to be able to work independently and safely on a defined practical laboratory task using scientific and practical methods.

(Intermediate) Certificate

See §22, para. 7 of the examination regulations: A test/intermediate test certifies that the student has completed a piece of coursework (e.g. draft) to the required standard. The scope of work to be completed and the required content and requirements can be found in the respective module description in the module handbook and in the assignment.

Open book preparation

The open book assignment (OBA) is a short term paper and therefore an unsupervised written or electronic examination. It is characterized by the fact that, according to the examiner's declaration of aids, all aids are generally permitted. Special attention is drawn to the safeguarding of good scientific practice through proper citation etc. and the requirement of independence in the performance of each examination.

Thesis

Bachelor's or Master's thesis as defined in the examination regulations §25ff: The Master's thesis is a written assignment. It should show that the student is capable of independently working on a topic from their subject area within a specified period of time, both in its technical details and in its interdisciplinary contexts, using scientific and practical methods. Interdisciplinary cooperation can also be taken into account in the final thesis.

Colloquium

Colloquium for the Bachelor's or Master's thesis as defined in the examination regulations §29: The colloquium serves to determine whether the student is able to present the results of the Master's thesis, its technical and methodological foundations, interdisciplinary contexts and extracurricular references orally, to justify them independently and to assess their significance for practice.

10. Profile Module Matrix

The following section describes the extent to which the modules of the degree program support and develop the competencies and fields of action of the study program as well as certain study program criteria as defined by the University of Applied Science TH Köln.

Abbr.	Module Name	HF1 - Algorithmen, Protokolle, ...	HF2 - Wissenschaftlich arbeiten...	HF3 - Fachliche Führungs- und P...	K.1 - kommunikationstechnische ...	K.2 - kommunikationstechnische ...	K.3 - kommunikationstechnische ...	K.4 - kommunikationstechnische ...	K.5 - kommunikationstechnische ...	K.6 - Komplexe Fragestellungen ...	K.7 - Informationen und wissens...	K.8 - Naturwissenschaftliche Ph...	K.9 - Erkennen und Verstehen te...	K.10 - MINT-Modelle nutzen	K.11 - MINT-Wissen anwenden	K.12 - MINT-Wissen bedarfsgerech...	K.13 - Technische und wissenscha...	K.14 - Eigene wissenschaftliche ...	K.15 - Arbeitsergebnisse bewerte...	K.16 - Wissenschaftliche Method...	K.17 - Wissenschaftliche Aussage...	K.18 - Regeln guten wissenschaft...	K.19 - Komplexe technische Aufga...	K.20 - In unsicheren Situationen...	K.21 - Gesellschaftliche und eth...	K.22 - Lernfähigkeit demonstrier...	K.23 - Sich selbst organisieren	K.24 - Sprachliche und interkult...	SK.1 - Global Citizenship	SK.2 - Internationalisierung	SK.3 - Interdisziplinarität	SK.4 - Transfer
ACC	Advanced Channel Coding	●	●		●	●	●	●	●				●	●		●	●													●	●	
AMC	Advanced Multimedia Communications	●	●		●	●	●	●	●	●			●				●														●	
AMS	Special Aspects of Mobile Autonomous Systems	●	●		●		●		●		●		●																			●	●
ARP	Alternative Rechnerarchitekturen und Programmiersprachen	●	●		●	●	●	●	●	●	●		●	●		●	●															
AVT	Audio- und Videotechnologien	●	●	●	●	●	●	●	●	●	●		●	●		●	●															
AVV	Algorithmen der Videosignalverarbeitung	●	●	●	●	●	●	●									●															
BSN	Fundamentals of System and Network Theory		●			●			●		●		●																		●	●	
CI	Computational Intelligence	●	●	●	●	●	●		●	●	●		●				●															
CSO	Computersimulation in der Optik	●	●	●	●	●	●		●	●	●		●	●																		
DBT	Digitale Bildtechnik	●	●			●	●		●		●		●																			
DLO	Deep Learning und Objekterkennung	●	●		●	●	●	●		●			●		●																	
DMC	Digital Motion Control	●	●		●	●			●	●	●	●	●		●	●																

Abbr.	Module Name	HF1 - Algorithmen, Protokolle, ...	HF2 - Wissenschaftlich arbeiten...	HF3 - Fachliche Führungs- und P...	K.1 - kommunikationstechnische ...	K.2 - kommunikationstechnische ...	K.3 - kommunikationstechnische ...	K.4 - kommunikationstechnische ...	K.5 - kommunikationstechnische ...	K.6 - Komplexe Fragestellungen ...	K.7 - Informationen und wissens...	K.8 - Naturwissenschaftliche Ph...	K.9 - Erkennen und Verstehen te...	K.10 - MINT-Modelle nutzen	K.11 - MINT-Wissen anwenden	K.12 - MINT-Wissen bedarfsgerech...	K.13 - Technische und wissenscha...	K.14 - Eigene wissenschaftliche ...	K.15 - Arbeitsergebnisse bewerte...	K.16 - Wissenschaftliche Method...	K.17 - Wissenschaftliche Aussage...	K.18 - Regeln guten wissenschaft...	K.19 - Komplexe technische Aufga...	K.20 - In unsicheren Situationen...	K.21 - Gesellschaftliche und eth...	K.22 - Lernfähigkeit demonstrier...	K.23 - Sich selbst organisieren	K.24 - Sprachliche und interkult...	SK.1 - Global Citizenship	SK.2 - Internationalisierung	SK.3 - Interdisziplinarität	SK.4 - Transfer
DSP	Digital Signal Processing	●	●		●	●	●		●				●			●														●		
EBA	Elektrische Bahnen	●	●		●	●	●		●	●		●	●				●															
EMM	Energiemanagement in Energieverbundsystemen		●	●		●	●	●	●	●	●	●	●	●		●																
HIM	Advanced Mathematics					●	●						●																	●		
HSUT	Hochspannungsübertragungstechnik	●	●		●	●	●		●	●		●	●				●															
IBD	InnoBioDiv				●	●	●		●	●	●						●													●	●	●	●
IIS	Intelligent Information Systems	●	●	●	●	●	●		●	●	●		●			●	●															
ITF	IT-Forensik	●			●	●	●	●	●				●	●		●	●															
KOGA	Kombinatorische Optimierung und Graphenalgorithmen	●	●		●	●	●		●	●	●					●	●															
KOLL	Kolloquium zur Masterarbeit	●	●	●					●	●																						
KRY	Cryptography	●	●		●	●			●				●																	●		
LCSS	Large and Cloud-based Software-Systems	●	●	●	●	●	●	●	●	●	●		●			●	●													●		●
LSPW	Leistungselektronische Stellglieder für PV- und Windkraftanlagen	●	●	●	●	●	●		●			●	●				●															
MAA	Masterarbeit	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●														●	●
MCI	Mensch-Computer-Interaktion	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●													●	●	

Abbr.	Module Name	HF1 - Algorithmen, Protokolle, ...	HF2 - Wissenschaftlich arbeiten...	HF3 - Fachliche Führungs- und P...	K.1 - kommunikationstechnische ...	K.2 - kommunikationstechnische ...	K.3 - kommunikationstechnische ...	K.4 - kommunikationstechnische ...	K.5 - kommunikationstechnische ...	K.6 - Komplexe Fragestellungen ...	K.7 - Informationen und wissens...	K.8 - Naturwissenschaftliche Ph...	K.9 - Erkennen und Verstehen te...	K.10 - MINT-Modelle nutzen	K.11 - MINT-Wissen anwenden	K.12 - MINT-Wissen bedarfsgerech...	K.13 - Technische und wissenscha...	K.14 - Eigene wissenschaftliche ...	K.15 - Arbeitsergebnisse bewerte...	K.16 - Wissenschaftliche Method...	K.17 - Wissenschaftliche Aussage...	K.18 - Regeln guten wissenschaft...	K.19 - Komplexe technische Aufga...	K.20 - In unsicheren Situationen...	K.21 - Gesellschaftliche und eth...	K.22 - Lernfähigkeit demonstrier...	K.23 - Sich selbst organisieren	K.24 - Sprachliche und interkult...	SK.1 - Global Citizenship	SK.2 - Internationalisierung	SK.3 - Interdisziplinarität	SK.4 - Transfer
MLWR	Maschinelles Lernen und wissenschaftliches Rechnen						●		●			●	●		●	●	●														●	●
NGN	Next Generation Networks	●	●		●	●	●	●	●	●			●				●														●	
NLO	Nichtlineare Optik	●	●	●		●	●		●	●	●		●																			
OSA	Optische Spektroskopie und Anwendungen	●	●	●	●	●	●	●	●	●	●		●	●		●	●															
PAP	Parallele Programmierung	●	●		●	●	●		●	●	●		●				●															
PM	Project Management	●				●			●	●	●		●																		●	●
QEKS	Qualitätsgesteuerter Entwurf komplexer Softwaresysteme	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●															
RFSD	RF System Design		●		●	●	●			●			●				●														●	●
RM	Rastermikroskopie	●	●			●	●	●	●	●	●		●			●																
RP	Research Project	●	●	●	●	●	●		●	●	●		●		●																●	●
SIM	Simulation in der Ingenieurswissenschaft	●	●	●	●		●	●	●				●	●		●	●															
SNEE	Stromnetze für erneuerbare Energien	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●															
SYE	Systemtechnik für Energieeffizienz	●	●	●		●	●	●		●		●	●	●		●																
TED	Theoretische Elektrodynamik		●				●			●	●		●																			
THI	Theoretische Informatik	●	●		●	●			●	●	●						●															

Abbr.	Module Name	HF1 - Algorithmen, Protokolle, ...	HF2 - Wissenschaftlich arbeiten...	HF3 - Fachliche Führungs- und P...	K.1 - kommunikationstechnische ...	K.2 - kommunikationstechnische ...	K.3 - kommunikationstechnische ...	K.4 - kommunikationstechnische ...	K.5 - kommunikationstechnische ...	K.6 - Komplexe Fragestellungen ...	K.7 - Informationen und wissens...	K.8 - Naturwissenschaftliche Ph...	K.9 - Erkennen und Verstehen te...	K.10 - MINT-Modelle nutzen	K.11 - MINT-Wissen anwenden	K.12 - MINT-Wissen bedarfsgerech...	K.13 - Technische und wissenscha...	K.14 - Eigene wissenschaftliche ...	K.15 - Arbeitsergebnisse bewerte...	K.16 - Wissenschaftliche Method...	K.17 - Wissenschaftliche Aussage...	K.18 - Regeln guten wissenschaft...	K.19 - Komplexe technische Aufga...	K.20 - In unsicheren Situationen...	K.21 - Gesellschaftliche und eth...	K.22 - Lernfähigkeit demonstrier...	K.23 - Sich selbst organisieren	K.24 - Sprachliche und interkult...	SK.1 - Global Citizenship	SK.2 - Internationalisierung	SK.3 - Interdisziplinarität	SK.4 - Transfer
TSVP	Technologien und Systeme der Videoproduktion		●				●	●	●																							
VAE	Virtual Acoustic Environments	●	●		●	●	●	●						●		●															●	●
VER	Virtuelle und erweiterte Realität	●	●		●	●	●	●	●	●	●	●	●		●	●	●															

11. Version History

The table below lists the different versions of the course offer. The versions are sorted in reverse chronological order with the currently valid version in the first row. The individual versions can be accessed via the link in the right-hand column on the right.

Version	Date	Changes	Link
3.11	2025-11-27-13-12-05.df79964d (SNAPSHOT)	1. Modul Wind Energy der F12 in Wahlbereich 2. Darstellung evtl. Kapazitätsbeschränkungen je Modul 3. Verweis auf Merkblatt Leistungspunkte-Berechnung im Wahlbereich der Studiengänge im Eingangstext zu Wahlbereichen	Link
3.10	2025-10-07-08-46-00	1. Korrektur der Turnusse von PM, QC, TAI, BSN, WIND, VDS 2. Abweichende Lehrveranstaltungkürzel in Klammern neben Modulkürzeln dargestellt, bspw. QEKS (SEKM) oder ERMK (GER) 3. Turnusse in Tabellen (Wahlbereiche, Studienschwerpunkte/Vertiefungspakete) dargestellt 4. Sortierbare Tabellen in Wahlbereiche, Studienschwerpunkte/Vertiefungspakete	Link
3.9	2025-09-08-09-32-00	1. Diverse hängende Referenzen von Wahlbereichs-, Schwerpunkts- bzw. Vertiefungspaket-Tabellen in den Modul-Abschnitt korrigiert. Fehlende Module sind jetzt vorhanden. 2. Eine Modulbeschreibung beinhaltet nun auch Angaben, in welchen Wahlbereichen und Studienschwerpunkten bzw. Vertiefungspakten das jeweilige Modul enthalten ist. 3. Prüfungsvorleistungen in BSN reduziert 4. CSO mit Prüfungsform für begleitende Prüfung 5. Prüfungsordnungsversionen statt Jahreszahlen 6. Modulkürzel ohne Studiengang	Link
3.8	2025-08-25-18-53-00	1. "Kommunikation in verteilten Systemen" als externes Modul der H-BRS statt internes F07-Modul	Link
3.7	2025-08-22-14-20-00	1. Distributed Systems for IoT in Schwerpunkt Networks and Security in MaCSN	Link
3.6	2024-12-06-08-45-55	1. Begutachtete Version für Reakkreditierung 2024 2. Neues Layout für sämtliche Modulhandbücher	Link
3.5	2024-07-06-12-00-00	1. Neues Modul "IT-Forensik" für Masterstudiengänge Technische Informatik, Medientechnologie und Elektrotechnik	Link
3.4	2024-02-23-15-00-00	1. Generelle Überarbeitung des Layouts 2. Eingangstexte bei Wahlmodulkatalogen und Schwerpunkten überarbeitet und POs angeglichen	Link
3.3	2023-09-01-14-30-00	1. Neue(s) Modul und Lehrveranstaltung "InnoBioDiv" im Master Communication Systems and Engineering, Technische Informatik	Link
3.2	2023-07-17-11-00-00	1. Masterarbeit in Master Communication Systems and Engineering auf Englisch (FR-2023-12)	Link
3.1	2023-03-06-14-00-00	1. Neue Lehrveranstaltung "Software Engineering für die Automatisierungstechnik", Modulbeschreibungen für Kolloquium und Masterarbeit im Master Communications Systems and Networks, externes Modul "Steuern" für X1 in Master Technische Informatik	Link
3.0	2023-02-24-20-00-00	1. Allgemeine Bereinigung von kaputten Links (http 404)	Link

Impressum | Datenschutzhinweis | Haftungshinweis | Bei Fehlern, bitte Mitteilung an die modulhandbuchredaktion@f07.th-koeln.de