Faculty of Information Systems and Applied Computer Sciences (WIAI)

Undergraduate and Graduate Studies in Information Systems and Computer Science

Module Handbook and Student Guide Academic Year 2024-2025



WIAI

www.uni-bamberg.de/wiai

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Contents

MODULE HANDBOOK AND STUDENT GUIDE ACADEMIC YEAR 2014-2015 1

1 INTRODUCTION AND GENERAL INFORMATION 4

1.1 Fees and Registration 4

1.2 Teaching Times 5

1.3 Assessment 5

1.4 Workload 6

1.5 Course Levels and Teaching Format 6

1.6 Other Information 7

2 INTRODUCING THE FACULTY'S TEACHING AND RESEARCH GROUPS 8

2.1 Applied Computer Science 8

AISE – AI Systems Engineering 8
KogSys – Cognitive Systems 8
CG – Computer Graphics 9
KInf – Computing in the Cultural Sciences 9
xAI – Explainable Machine Learning 10
NLproc – Fundamentals of Natural Language Processing 10
HCI – Human-Computer Interaction 11
VIS – Information Visualization 11
MI – Media Informatics 12
MII – Multimodal Intelligent Interaction 12
DS – Natural Language Generation and Dialogue Systems 13
UxD – User Experience and Design 13

2.2 Computer Science 14

AlgoK – Algorithms and Complexity Theory 14
KTR – Communication Systems and Computer Networks 14
DT – Data Engineering 15
DSG – Practical Computer Science (Distributed Systems) 15
GdI – Foundations of Computer Science 16
MOBI – Chair of Mobile Systems 16
PSI – Privacy and Security in Information Systems Group 16
SWT – Software Technologies Research Group 17
SYSNAP – Systems Programming 17

2.3 Information Systems 18

DW – Digital Work 18
EESYS – Energy Efficient Systems 18
ISHANDS – Health and Society in the Digital Age 18
IIS – Industrial Information Systems 19
ISDL – Information Systems in the Service Industry 19
ISM – Information Systems Management 20
AIC – AI Engineering in Companies 20
ISPL – Information Systems and Digital Platforms 21
SNA – Social Networks 21

3 MODULE DESCRIPTIONS 22

1 Introduction and General Information

This handbook lists all modules offered in the Faculty of Information Systems and Applied Computer Sciences during the academic year 2024-2025.

To prevent problems arising from late changes on these offerings, you are advised to confirm module specifications and schedules through the research groups' web pages or directly with the responsible teaching staff. There may also be new courses becoming available on short notice. Please see the faculty's web pages for relevant announcements. The official German module handbooks for the various degree courses can be accessed through the following links:

- B.Sc. Angewandte Informatik
- B.Sc. International Information Systems Management
- B.Sc. Informatik: Software Systems Sciences
- B.Sc. Information Systems (Wirtschaftsinformatik)
- M.Sc. Applied Computer Sciences
- M.Sc. Computing in the Humanities
- M.Sc. International Software Systems Science
- M.Sc. Information Systems (Wirtschaftsinformatik)
- M.Sc. International Information Systems Management

1.1 Fees and Registration

All modules are currently open free of charge to foreign guest students who will study at Bamberg University within the frame of a partnership exchange programme, such as ERASMUS+. There are no tuition or bench fees. Enrolment with the University incurs a nominal registration fee covering administration charges, student union membership (*Studierendenwerk*) and the City of Bamberg travel ticket.

Information on the registration and enrolment process may be obtained from the International Office who will also be able to advise you on any exchange scheme that may exist between Bamberg University and your home institution.

Once admitted to and enrolled with Bamberg University you do not need to register for attending a teaching module. Feel free to sit in and participate in any course offering that fits your educational needs and time table. Be aware, though, that some courses may have entry requirements and/or class size restrictions.

1.2 Teaching Times

The academic year 2024-2025 consists of two teaching periods. Winter semester at Germany Universities always starts on October, 1st, and ends on March, 31st. Summer semester always starts on April, 1st, and ends on September, 30th. Lectures usually start two weeks later:

- Winter Semester lecture start: 14th October 2024 – 07th February 2025,
- Summer Semester lecture start: 23th April 2025 – 25st July 2025.

All deadlines and dates can be also found here: https://www.uni-bamberg.de/en/studies/currently-enrolled/study-organization/deadlines-and-dates/

1.3 Assessment

The course assessment is done mostly by written exams and optionally also by way of homework assignments and/or lab practicals. In a number of cases, typically for graduate level modules, the final exam is oral.

Final written exams are usually held immediately after the end of the lecture period, i.e. February/March for the Winter Semester and end of July/August for the Summer Semester. Make sure you plan your travelling so you are in Bamberg during the exams.

Be aware that there are firm deadlines for exam registration some time at the end of the first half of the semester. Watch out for the emails announcing the registration period and check up with your class mates if you are not sure. There is a short period of time during which you can deregister from an exam. Once this period has passed and you are registered you **must take** the exam at the specified day and time. Also, if you miss the online registration deadline, then you **cannot participate** in the exam.

There is one more thing to know: For written exams the registration in FlexNow2 is sufficient. For oral exams, however, you also need to arrange an exam time with the lecturer in addition to the FlexNow2 registration.

If for some reason you cannot attend the regular written exam, say because you are required to return home early, talk to the course lecturer before the FlexNow2 registration period has passed. There are two options:

- **Option 1:** The course lecturer may be able to arrange an oral exam for you at an earlier date instead.

  In this case, because you are not writing the official exam, you **must not register** with the FlexNow2!

  system.

- **Option 2:** It is sometimes possible that we schedule the regular exam at your Home University on the same day and at the same time when it is written in Bamberg. For this option you **must register** via FlexNow2!

Please contact the Career & International Center early to obtain advice on how to arrange remote exams. Whether such options are available is entirely at the discretion of the course lecturer.

The official exam language is German, but many courses may offer written or oral exams in English if required. Some modules are fully taught in English, some only at the discretion of the lecturer. If you need to be set an English exam for a module delivered in German you should contact the module lecturer early to find out if this is possible. The description of each module listed below in this booklet indicates if all or some part of the module is delivered in English.

1.4 Workload

The module descriptions below specify the total module workload in terms of ECTS (European Credit Transfer System) credit points according to the following approximate accounting scheme:

- 1 ECTS = 25-30 hrs total student workload (all inclusive)
- 30 ECTS = total module load per semester
- 6 ECTS = single standard course module of 4 contact hrs/week, combining lectures + tutorials

1.5 Course Levels and Teaching Format

In line with our traditional Diploma degree structure, modules are taught at 2 levels:

- *Basic Studies*

  These are foundational and introductory courses in the general disciplines of Information Systems, Applied Computer Science and Software Systems Science corresponding to the 1st and 2nd year of the undergraduate B.Sc. programmes.

- *Advanced Studies*

  These are introductory courses to specialized fields within Information Systems, Applied Computer Science and Software Systems Science corresponding to the 3rd year of the B.Sc. degree and advanced modules in particular research areas which correspond to the 1st and 2nd year of the graduate M.Sc. programmes.

As our guest students you may attend modules at any of these levels. It is your responsibility to judge if your background will be sufficient to participate successfully in the course. Also, whether or not the credits you earn are valid towards your home degree, is not decided by us, but by your home institution.

Keep in mind, however, that graduate level modules normally assume a significant amount of background in the relevant subject area.

Most modules are based on combined lectures and tutorials. Some courses may also involve lab classes, excursions, blended learning and other teaching arrangements. Research groups regularly offer advanced level seminars and project modules on varying research topics. These may have special entry prerequisites.

1.6 Other Information

The International Office provides information on accommodation, living expenses, language courses and many other aspects of student life at Bamberg.

International Office

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Secretary - Foreign Student Affairs

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URL: https://www.uni-bamberg.de/international-office/

You are also welcome to contact the International Affairs Representative of the WIAI Faculty (see address page 2).

The Faculty of Social Sciences, Economics and Business Administration's UNICOACH can be found here:

https://www.uni-bamberg.de/en/sowi/studies/studying-internationally/studying-in-bamberg/exchange-studies/

UNICOACH is a series of short videos providing information on important student life issues like "*how to understand the university system*" or „*how to register for classes and exams*".

2 Introducing the Faculty's Teaching and Research Groups

2.1 Applied Computer Science

AISE – AI Systems Engineering

Prof. Dr. Christoph Benzmüller

Chair of Information Visualization

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Our research activities are interfacing the areas of artificial intelligence, philosophy, mathematics, computer science, and natural language. Current research focuses on the use of formal argumentation & explanation to achieve trustworthy AI systems, that is reasonable machines. I am particularly interested in the use of classical higher-order logic (HOL) as a universal meta-logic to automate various non-classical logics and to utilise them in topical application areas, including machine ethics & machine law, metaphysics (e.g. Gödel's ontological argument), mathematical foundations (e.g. category theory) and rational argumentation. My research activities also address the integration of automated reasoning, machine learning and agent-based architectures. I have a core expertise in classical higher-order logic (HOL), and I have contributed to its semantics and proof theory, and together with colleagues and students I have developed the Leo theorem provers for HOL.

KogSys – Cognitive Systems

Prof. Dr. Ute Schmid

Head of Cognitive Systems Group

Office 05.043

An der Weberei 5

96047 Bamberg

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Internet: http://www.uni-bamberg.de/kogsys

In the research domain Cognitive Systems (CogSys) we are concerned with the development of approaches, concepts, and methods for design, description, construction and analysis of intelligent systems based on cognitive principles. Our research strategy is to combine empirical studies of cognitive phenomena, development of algorithms, and their testing in different areas of application. Main topics of our group are induction and learning as well as planning and problem solving in single- and multi-agent settings. Especially, we are interested in the inductive synthesis of recursive functional programs from incomplete specifications (e.g., input/output examples) which can be seen as a general approach to learning productive rules from experience. Furthermore, we investigate analogical reasoning as a powerful approach to problem solving as a special mechanism of knowledge acquisition.

Application areas are, for example, support of human problem solvers in the domains of software development, classifier learning for medical diagnostics, quality control, decision support or incident mining and assistant systems for activities of daily life.

CG – Computer Graphics

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Chair of Computer Graphics and its Foundations
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Research in the Computer Graphics Group revolves around virtual characters, motion perception, virtual reality and augmented reality, as well as character animation.

KInf – Computing in the Cultural Sciences

Prof. Dr. Christoph Schlieder
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Internet: http://www.uni-bamberg.de/kinf/

In research and teaching, we focus on computational issues relevant to the cultural sciences. At our laboratory we develop software solutions that assist, for instance, preservation scientists working with built heritage or sociologists studying web-based communication processes. Technologically speaking, our software relies on methods from semantic information processing that we continue to improve. Our key areas of interest are Geoinformation systems and services, Digital libraries and archives, Mobile assistance systems, and Computer-mediated communication.

xAI – Explainable Machine Learning

Prof. Dr. Christian Ledig
Chair of Explainable Machine Learning
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Mail: christian.ledig@uni-bamberg.de
Internet: https://www.uni-bamberg.de/xai/

The research group focuses on the development of robust, data-efficient methods of machine learning with varied applications in the industry and especially in the healthcare sector. The overarching goal is to make a positive contribution to the society, or human wellbeing respectively. You can find a detailed description of our research areas on our website in the section "research focus". Our teaching activities include courses on Deep Learning and Mathematics for Machine Learning for Master students as well as several Seminars and Projects for Bachelor and Master students. We teach in English and our exams and course material are also in English.

NLproc – Fundamentals of Natural Language Processing

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Chair of Fundamentals of Natural Language Processing
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Internet: https://www.uni-bamberg.de/en/nlproc/

We work on processing natural language in written form, that means, we perform research to enable computers to understand language (natural language understanding) and also to generate language (natural language generation). We cover all steps in this research and development process, including

- Resource Development (we need data that exemplify the phenomena we want to model)
- Modeling (we develop machine learning models, often based on deep learning, probabilistic methods, or large language models), which learn from these data
- Application (we apply the systems we develop across various areas to understand their limitations and help other areas to benefit from the value of such systems)

The BamNLP group focuses on a set of NLP topics:

- Modeling of psychological concepts (emotions, intend, belief, deception, argumentation, persuasion)
- Interdisciplinary research (digital humanities, computational psychology, computational social sciences, corpus linguistics, biomedical NLP)

- Fundamental NLP and machine learning research (deep learning, large language models, probabilistic graphical models)

HCI – Human-Computer Interaction

Prof. Dr. Tom Gross
Chair of Human-Computer Interaction
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Internet: http://www.uni-bamberg.de/hci

Human-Computer Interaction (HCI) aims at optimally supporting users through technology (mainly computer technology) by amplifying their strengths and compensating their weaknesses. The Special Interest Group HCI of the German Informatics Society provides the following definition: "The field of Human-Computer Interaction comprises the analysis, design, and evaluation of human- and task-centred computer applications" (in German). In the context of HCI interactive systems are often mentioned—an interactive (computer-) system thereby is described as a unity consisting of software and hardware that receives input from users and gives immediate feedback. The usability of interactive systems can be evaluated along three factors: effectiveness (accuracy and completeness with which users achieve their goals), efficiency (resources expended by users to achieve these goals), and satisfaction (the users' positive attitudes towards the use of the system).

VIS – Information Visualization

Prof. Dr. Fabian Beck
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We envision to help people understand data. We design and implement novel visualizations that support users in effectively analyzing complex data and gain new insights. We offer student theses and projects in the area of information visualization and visual analytics.

MI – Media Informatics

Prof. Dr. Andreas Henrich
Chair of Media Informatics
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Mail: andreas.henrich@uni-bamberg.de
Internet: http://www.uni-bamberg.de/minf/

Media Informatics aims at a purposeful application of single media types and multimedia systems in various application areas. It considers aspects like media technique, media design, media storage and retrieval as well as the use of media with a focus on the development of multimedia systems. The main focus of this chair is on media storage and retrieval and the development of domain specific multimedia applications.

MII – Multimodal Intelligent Interaction

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Chair of Multimodal Intelligent Interaction
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Internet: https://www.uni-bamberg.de/mii/

The areas of research at the group include robotics, human-robot interaction, intelligent systems, autonomous handling of complex tasks, and joint action scenarios between humans and robots. An intelligent system must be able to understand and solve complex tasks if it is to interact autonomously with its environment. This poses a number of challenges: unstructured environments require flexible solutions in order to be able to react to external factors. In addition, tasks can usually be solved in different ways and must be adapted to the capabilities of the robot system. Ambiguities in the interaction with users result in unclear instructions that need to be supplemented to be fully understood, e.g., from the context. In addition to the need for anticipating human behavior and supporting a variety of modalities, commonsense and domain knowledge must also be represented. The combination of symbolic and subsymbolic AI in a hybrid approach is central to this. Furthermore, social aspects must also be taken into account in this kind of interaction between robots and humans.

DS – Natural Language Generation and Dialogue Systems

Prof. Dr. Stefan Ultes
Chair of Natural Language Generation and Dialogue Systems
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Gutenbergstraße 13
96047 Bamberg
Mail: stefan.ultes@uni-bamberg.de
Web: https://www.uni-bamberg.de/ds/

The Natural Language Generation and Dialogue Systems Group conducts research within the broad field of Conversational AI and spoken dialogue systems focussing on methods and technology to realise natural voice-first interaction between humans and machines. Employing machine learning methods, the group's research addresses the following questions: which properties and abilities must a system have to act in a natural manner, which factors make the behaviour of the system to be perceived as natural, and how to realise this natural interaction from a technical point of view. In other words, the goal is to understand all factors that constitute "natural system behaviour" in the context of spoken interaction.

UxD – User Experience and Design

Prof. Dr. Patrick Tobias Fischer
Chair of User Experience and Design
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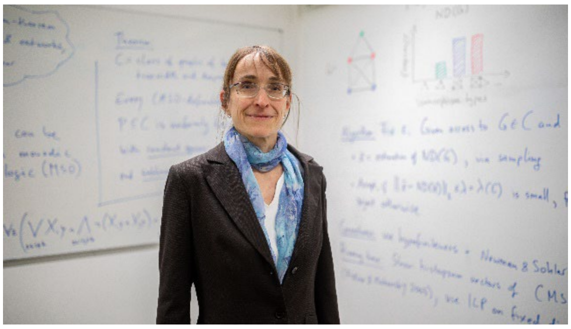
Internet: https://www.uni-bamberg.de/uxd/

At the chair of User Experience and Design our teaching activities center on Urban Interaction Design, Interface Design and Multimodal Experiences. We develop knowledge for and through design. By prototyping novel types of interaction and interfaces we explore experiential and sociopragmatic values, relationships, materiality and behaviour in the context of public life and urban environments. To unlock the students and our creative potential and imagine novel interactive situations, we constantly learn about and engage with a variety of design materials. Sensors, actuators, micropocessors, blue foam, paper, 3D prints, 2- and 3D-graphics, artificial intellicence, behavioural patterns, etc. are just a few to name. Combined with theoretic knowledge from Urban Design, MediaArchitecture and HCI novel ways of user experiences are shaped to discover new knowledge.

2.2 Computer Science

AlgoK – Algorithms and Complexity Theory



Prof. Dr. Isolde Adler
Chair for Algorithms and Complexity Theory
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Mail: isolde.adler@uni-bamberg.de
Internet: https://www.uni-bamberg.de/algok/

Research at the chair is centred around the design of efficient algorithms (with guarantees) for discrete structures, with a particular interest in the interplay between efficiency and the combinatorial structure of the input instances. For example, many classical problems on graphs are NP-hard in general, but they lie at the core of numerous applications, so they need to be solved in practice. These problems include the famous Graph Colouring Problem, the Hamiltonian Cycle Problem, and many others. However, if we restrict the inputs to trees or "tree-like" graphs, many of these problems become efficiently solvable.

We aim to push the boundaries of efficient solvability, with new algorithms tailored to the structure of the input instances, and complementing the picture by proving lower bounds. We are interested in classical and modern algorithms, such as parameterised algorithms, sublinear time algorithms, and property testing.

Beyond Algorithms and Complexity Theory, our research draws from the areas of Graph Theory, Logic and Combinatorics, Algorithmic Model Theory, and many more.

Our research has applications in a wide range of areas beyond graphs and networks, including database query evaluation, model checking and verification, combinatorial games, compiler construction, and AI.

KTR – Communication Systems and Computer Networks

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Head of Computer Networks Group
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Research and development of the group is devoted to traffic and network management of current telecommunication networks and future IP based fixed and mobile computer networks. Current research topics include the evaluation of resource management processes in wireless local IP networks, the development of QoS management architectures for IP communication networks, teletraffic theory and performance evaluation of such distributed systems, the statistical analysis and characterization of Internet traffic, and the estimation of corresponding generic model parameters.

DT – Data Engineering

Prof. Dr. Maximilian E. Schüle
Data Engineering
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96047 Bamberg
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Internet: http://www.uni-bamberg.de/en/dt

The data engineering group at university of Bamberg teaches concepts for database systems including advanced SQL for Master students, systems programming in C++ as introductory course for Bachelor and as advanced course for Master students. Within one seminar per semester for each Bachelor and Master students, we discuss current trends in database research based on conference papers.

DSG – Practical Computer Science (Distributed Systems)

Prof. Dr. Guido Wirtz
Chair of Practical Computer Science
Distributed Systems Group
Office 03.016
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96047 Bamberg
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Internet: http://www.uni-bamberg.de/en/pi

Besides introductionary courses for 1th and 2nd year students, our teaching activities put an emphasis on combining the theoretical background of distributed systems with knowledge about middleware and architecture for complex systems. This is done by advanced courses and seminars as well as practical labs to get hands-on experience with real-life systems. All courses require hands-on programming using recent technologies like, e.g., gRPC, REST, Microservices, ...

The DSG's research directions are centered on issues regarding the software development for complex, esp. distributed, systems on all levels. Our current research activities are focussed on the seamless transition from business processes to their implementation in a SOA and cloud context, Microservice architectures, as well as new approaches for the Internet-of-Things (IoT) like Edge- and Fog-Computing as well as in modern cloud techniques like, e.g. Serverless computing.

GdI – Foundations of Computer Science

Prof. Michael Mendler, PhD (Edinburgh)

Informatics Theory Group

Office 03.26

Gutenbergstraße 13

96050 Bamberg

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Internet: http://www.gdi.uni-bamberg.de

The group teaches the foundational aspects of computer science in all degree programmes, such as logic, automata and formal language theory, functional programming and the theory of distributed systems. In our research we are mainly concerned with constructive modal logic and type theory and their applications as well as the semantics of synchronous programming languages.

MOBI – Chair of Mobile Systems

Prof. Dr. Daniela Nicklas

Chair of Information Systems, esp. Mobile Software Systems / Mobility

Office 05.128

An der Weberei 5

96047 Bamberg

Mail: daniela.nicklas@uni-bamberg.de

Internet: https://www.uni-bamberg.de/en/mobi/

The MOBI focuses on data management for mobile systems, data stream management/complex event processing and development support for sensor-based applications, in the area of smart cities.

PSI – Privacy and Security in Information Systems Group

Prof. Dr. Dominik Herrmann

Chair of Information Systems and Applied Computer Sciences, esp. Privacy and Security Information Systems

Office 05.030

An der Weberei 5

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Internet: https://www.uni-bamberg.de/en/psi/

The focus of the PSI Group is the protection of information systems and the protection of privacy with technical mechanisms. To this end, the PSI Group analyzes and evaluates existing systems and develops protective mechanisms. The PSI Group cooperates with working groups in the fields of machine learning (inference attacks, online tracking), law (data protection, law enforcement) and ethics (value-oriented system design).

SWT – Software Technologies Research Group

Prof. Dr. Gerald Lüttgen
Head of Software Technologies Research Group
Office 03.014
An der Weberei 5
96047 Bamberg
Internet: www.uni-bamberg.de/swt/

The Software Technologies Research Group (SWT) specializes in the quality assurance of complex software systems based on model-centric engineering and formal analysis. Specific areas of expertise are software testing, automated verification, program comprehension, concurrency theory, synchronous real-time systems, and intelligent cyber-physical systems. Students enrolling in SWT modules are expected to have a strong interest in software engineering and modelling, be proficient in mathematical and computational thinking, and show a high degree of commitment to learning.

SYSNAP – Systems Programming

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Practical Computer Science, esp. Systems Programming
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Internet: https://www.uni-bamberg.de/sysnap/

We are currently in the process of building the group and additional content will follow shortly

2.3 Information Systems

DW – Digital Work

Prof. Dr. Gerit Wagner

Junior Professorship for Digital Work

Office 01.081

An der Weberei 5

96047 Bamberg

Mail: gerit.wagner@uni-bamberg.de

Internet: https://www.uni-bamberg.de/digital-work/

More information coming soon.

EESYS – Energy Efficient Systems

Prof. Dr. Thorsten Staake

Chair of Information Systems, esp. Energy Efficient Systems

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Internet: http://www.uni-bamberg.de/eesys

The Energy Efficient Systems Group focuses on the development of Information Systems (IS) for supporting and motivating sustainable consumer behavior. Particular consideration is given to smart metering and smart grid infrastructure and the design of related systems that enable energy efficiency services for private households. With a clear focus on the development and assessment of applications that are applicable to the mass market, the group closely works together with both, industry partners and startup companies. The research results build an important cornerstone of the teaching activities at bachelor and master level.

ISHANDS – Health and Society in the Digital Age

Prof. Dr. Christian Maier

Chair of Information Systems, esp. Energy Efficient Systems

Office 01.30

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Internet: https://www.uni-bamberg.de/en/ishands/

We focus on digital transformation and its impact on people and companies and on how digital technologies affect individual well-being (e.g., burnout, technostress, eustress). In another research stream, we explain that shocks (e.g., data breaches, a new job) cause people to stop using digital services such as Netflix or Spotify. Another research stream addresses specific questions around current contexts such as Generative Artificial Intelligence (GenAI), Blockchain/Bitcoin, and social networking sites. The research methods used are quantitative and qualitative, with different data collection forms such as interviews, case studies, diaries, (cross-sectional and longitudinal) questionnaires, and experiments.

IIS – Industrial Information Systems

Prof. Dr. Sven Overhage
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The Chair of Industrial Systems focuses on the design and the operation of industrial information systems, which are the backbone of production and commerce businesses. We offer courses for bachelor, master, and PHD students alike. Amongst others, our courses focus on the development and design of application systems, enterprise architecture management, electronic business, intra-organizational systems, and modular and on-demand systems.

ISDL – Information Systems in the Service Industry

Prof. Dr. Tim Weitzel
Chair of Information Systems, esp. Information systems in the service industry
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The four main research areas of the ISS team are (1) Business-IT Alignment and Business Value of IT, (2) (Social) Networks and IT, (3) IT Adoption and Usage and (4) Outsourcing Management. You can find a detailed description of our research projects in the section "for researchers". Our research results have been published in scientific journals and conferences.

ISM – Information Systems Management

Prof. Dr. Daniel Beimborn

Chair of Information Systems, esp. Information Systems Management

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Internet: http://www.uni-bamberg.de/iis

In research and teaching the Chair of ISM deals with questions concerning the management of information systems and technologies as well as with the challenges of digital innovation and transformation. The management of the information systems (IS) of an organization - consisting of those technical and personnel components, which are involved in the production, processing and use of information - is in particular in the 'age of digitization' an elementary component of successful organization management.

AIC – AI Engineering in Companies

Prof. Dr. Milad Mirbabaie

Chair of Information Systems, especially AI Engineering in Companies

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Internet: https://www.uni-bamberg.de/en/aic/

The Chair of AI Engineering in Companies (AIC) focuses on comprehensive research and teaching related to digital transformation, emphasizing the digital society. Our primary focus is on socio-technical systems that define the interaction between new technologies and people. We are particularly interested in how these interactions affect individuals, society, and businesses. Our key research areas include AI-based systems, digital assistants, digital detox, ethics in AI, crisis communication, crisis management, and social media. We explore how AI can enhance organizational processes, the role of digital assistants and the importance of balancing technology use through digital detox. Ethical considerations in AI, effective crisis communication and management, and the impact of social media are also central to our work. In our teaching, we prepare students to navigate and lead in a digitally transformed world, offering courses and research opportunities in these cutting-edge topics.

ISPL – Information Systems and Digital Platforms

Prof. Dr. Thomas Kude
Chair of Information Systems and Digital Platforms
Office GU13/02.06
Gutenbergstr. 13
96050 Bamberg
Mail: thomas.kude@uni-bamberg.de
Internet: https://www.uni-bamberg.de/en/wi/ispl/

Our current teaching offer includes courses on the management of digital platforms and the role of digital platforms in industries and society, as well as research seminars. The courses draw on current research insights and cover topics that are highly relevant for individuals, organizations, and policy makers.

In our research, we use qualitative and quantative methods to study digital innovation produced by collectives of organizations and individuals. For example, we study the governance and evolution of digital platforms and ecosystems in different domains, including enterprise software and mobile apps, or collaboration in teams, in particular in the context of software development.

SNA – Social Networks

Prof. Dr. Oliver Posegga
Chair in Information Systems, esp. Social Networks
Office 01.056
An der Weberei 5
96047 Bamberg
Mail: oliver.posegga@uni-bamberg.de
Internet: http://www.uni-bamberg.de/sna

We dedicate our work to research and education on the role of information systems in social networks and the use of social media (e.g. blogs, wikis) for managing knowledge within and between organizations as well as on digital transformation. We conduct theoretical and empirical research and collaborate with industry partners in these fields.

3 Module Descriptions

The following appendix titled "Module Handbook – International Studies" describes in detail all modules scheduled to run during 2024-2025.

The module handbook starts with an index of all modules listed by the area of studies. In Section 1 of the list *International Studies taught in English (on demand)* you find all modules that are offered in English either regularly or on demand. In the latter case, since the lecture may be in German if all students are German-speaking, you need to tell the lecturer before the semester if you require English tuition. Modules listed in Section 2 of the list *Exams in English on demand, though course material often in German, may sometimes be available in English* are delivered in German but (again "on demand'') are examined in English if requested. To find out more information please consult the detailed module descriptions or contact the module lecturer. Within each Section the modules are organised by subject group (Applied Computer Science, Computer Science, Information Systems) and further by the name of the Teaching and Research Group who are responsible for the offering.

The index of a single module lists its acronym, its title, how many ECTS credit points it comprises, in which semester it is offered and on which page you can find its full description. For example, here is a description of the information related to the module "PSI-IntroSP-B":

1	2	3	4	5
PSI-IntroSP-B	Introduction to Secrurity and Privacy	6,00 ECTS	every winter semester	page number

1. "PSI-IntroSP-B":
    a. "PSI" stands for the research group that provides the module; in this case, this is "PSI - Privacy and Security in Information Systems Group"
    b. "IntroSP" is the short form of the module title; here, this is Introduction to Secrurity and Privacy
    "B" stands for "Bachelor" which means the module is suggested for undergraduate students. The ending "M" indicates the recommendation that the module should be attended by graduate astudents.

    NOTE: International Exchange Students may attend any module offered, at undergraduate or graduate level.
2. "Introduction to Secrurity and Privacy": This is the title of the module
3. "6,00 ECTS": ECTS indicate the work load for the module (see "Sec. 1.4 Workload")
4. The module is offered every winter semester
5. The page on which you find a detailed module description.

Modules

AIC-HYIN-M: Hybrid Intelligence....15

AIC-SPRO-M: Research Project: Digital Society and AI-based Systems....17

AIC-WPRO-B: Practical Project: Human AI Collaboration....19

AISE-ETH: Ethics and Epistemology of AI....21

AISE-FTAIP-B: Frontier Topics in AI and Philosophy....24

AISE-PLM-V: Computational Metaphysics -- Mechanizing Principia Logico-Metaphysica....28

AISE-Proj-B: Bachelorprojekt KI-Systementwicklung....30

AISE-ProjPrak-UR: Universal Reasoning (in Philosophy, Mathematics and Computer Science)....33

AISE-Sem-M: Masterseminar zu KI-Systementwicklung (Oberseminar)....35

AISE-SemCP-B: Bachelorseminar Computational Philosophy....37

AISE-UL: Universal Logic & Universal Reasoning....39

AlgoK-AK-B: algorithms and complexity....42

AlgoK-Sem-B: Bachelor Seminar Algorithms and Complexity Theory....45

AlgoK-Sem-M: Master Seminar Algorithms and Complexity Theory....46

AlgoK-TAG: Baumzerlegungen, Algorithmen und Spiele....47

CG-ProjCGA-B: Project Computer Graphics....49

CG-ProjCGA-M: Project Computer Graphics....51

CG-ProjVRAR-B: Project Virtual Reality / Augmented Reality....52

CG-ProjVRAR-M: Project Virtual Reality / Augmented Reality....53

CG-SemCGA-B: Seminar Computer Graphics and Animation....54

CG-SemVRAR-B: Seminar Virtual Reality / Augmented Reality....55

CG-VRAR-M: Virtual Reality / Augmented Reality....56

DS-ConvAI-M: Advanced Dialogue Systems and Conversational AI....58

DS-Proj-M: Project Dialogue systems....60

DS-Sem-M: Master Seminar Conversational AI....62

DSG-IDistrSys-B: Introduction to Distributed Systems....64

DT-CPP-B: Introduction into Systems Programming in C++....67

DT-CPP-M: Advanced Systems Programming in C++ (Master)....68

DT-DB4MLKD-B: Modern Database Systems for Machine Learning and Knowledge Discovery....70

DT-DBCPU-M: Database Systems for modern CPU....71
DT-Proj-B: Bachelor Project: Data Engineering....73
DT-Proj-M: Project: Data Engineering....74
EESYS-ADAML-M: Applied Data Analytics and Machine Learning in R....75
EESYS-BIA-M: Business Intelligence & Analytics....78
EESYS-DDS-M: Data-driven Decision Support....81
EESYS-ES-M: Energy Efficient Systems....83
EESYS-P-DINU-M: Project Digital Nudges for Behavior Change in Enterprise Information Systems....86
GdI-CSNL-M: Computational Semantics of Natural Language....89
GdI-FPRS-M: Functional Programming of Reactive Systems....91
GdI-GTI-B: Machines and Languages....94
GdI-IFP-M: Introduction to Functional Programming....96
GdI-MTL-B: Modal and Temporal Logic....98
GdI-Proj-B: Foundations of Computing Project....100
GdI-Proj-M: Master's Project Theoretical Foundations of Computing....102
GdI-Sem-B: Seminar Foundations of Computing....104
GdI-Sem-M: Master's Seminar Theoretical Computer Science....105
HCI-DFM-M: Design and Research Methods of Human-Computer Interaction....107
HCI-DISTP-B: Design of Interactive Systems: Theory and Practice....110
HCI-IS-B: Interactive Systems....112
HCI-KS-B: Cooperative Systems....115
HCI-MCI-M: Human-Computer Interaction....118
HCI-Proj-B: Project Human-Computer Interaction....121
HCI-Proj-M: Project Human-Computer Interaction....123
HCI-Proj1-M: Research-Project Human-Computer Interaction....125
HCI-Proj2-M: Research-Project Human-Computer Interaction....127
HCI-Prop-M: Propaedeutic: Human-Computer-Interaction....129
HCI-Sem-B: Bachelor-Seminar Human-Computer Interaction....131
HCI-Sem-HCC-M: Master-Seminar Human-Centred Computing....133
HCI-Sem-M: Master-Seminar Human-Computer Interaction....135
HCI-US-B: Ubiquitous Systems....137

HCI-Usab-M: Usability in Practice....................140
IIS-Sem-B: Bachelor Seminar Industrial Information Systems.................... 142
IIS-Sem-M: Master Seminar Industrial Information Systems....................143
ISDL-DEXP-B: Digital Experimentation....................144
ISDL-ISS2-M: Optimization of IT-Reliant Processes.................... 146
ISDL-ISS3-M: IT Business Value....................151
ISHANDS-Change-M: Digital Change Management....................154
ISHANDS-Health-M: Digital Health....................157
ISM-DSI-M: Global Collaboration and Digital Social Innovation....................160
ISM-IOM-M: International Outsourcing Management.................... 163
ISPL-DIGB-B: Digital Business.................... 166
ISPL-DPIS-M: Digital Platforms in Industries and Society....................168
ISPL-FIISM-B: Fundamentals of International IS Management....................170
ISPL-MASI-B: Supplier relationships and mergers & acquisitions in the software industry.................... 173
ISPL-MDP-M: Managing Digital Platforms....................175
Inf-DM-B: Discrete Modeling....................177
KogSys-KI-B: Introduction to Artificial Intelligence....................179
KogSys-Proj-B: Bachelor Project Cognitive Systems.................... 182
KogSys-Sem-B: Bachelor Seminar Cognitive Systems....................184
MII-ProjCR-B: Bachelor Project Cognitive Robotics.................... 186
MII-ProjCR-M: Master Project Cognitive Robotics....................187
MII-SemHRI-B: Bachelor Seminar Human-Robot Interaction....................188
MII-SemHRI-M: Master Seminar Human-Robot Interaction.................... 189
MOBI-ADM-M: Advanced Data Management....................190
MOBI-DSC-M: Data Streams and Complex Event Processing.................... 192
MOBI-PRS-M: Master Project Mobile Software Systems (SoSySc)....................194
MOBI-Proj-B: Bachelor Project Mobile Software Systems.................... 196
MOBI-Proj-M: Master Project Mobile Software Systems....................198
MOBI-SEM-B: Bachelor-Seminar Mobile Software Systems....................200
MOBI-SEM-M: Master-Seminar Mobile Software Systems.................... 201
NLProc-ANLP-M: Applied Natural Language Processing....................202

NLProc-ILT-M: Impact of Language Technology....204
NLProc-PGM4NLP-M: Probabilistic Graphical Models for Natural Language Processing....206
NLProc-Sem1-M: Master Seminar Natural Language Processing 1....208
NLProc-Sem2-M: Master Seminar Natural Language Processing 2....210
PSI-AdvaSP-M: Advanced Security and Privacy....212
PSI-DiffPriv-M: Introduction to Differential Privacy....215
PSI-EDS-B: Ethics for the Digital Society....217
PSI-IntroSP-B: Introduction to Security and Privacy....219
PSI-ProjectCAD-M: Project Complex Attacks and Defenses....222
PSI-ProjectPAD: Project Practical Attacks and Defenses....225
PSI-ProjectSP-M: Project Security and Privacy....228
PSI-SSSProject-B: Software Systems Science Project: Security and Privacy....230
PSI-Sem-B: Seminar Security and Privacy Foundations....232
PSI-Sem-M: Seminar Research Topics in Security and Privacy....234
SNA-ASN-M: Social Network Analysis....236
SNA-NET-M: Network Theory....238
SNA-OSN-M: Project Online Social Networks....240
SNA-WIM-B: Knowledge- and Informationmanagement....242
SWT-ASV-M: Applied Software Verification....244
SWT-FPS-B: Foundations of Program Semantics....246
SWT-FSE-B: Foundations of Software Engineering....249
SWT-PR1-M: Masters Project in Software Engineering and Programming Languages....251
SWT-SEM-B: Seminar in Software Engineering and Programming Languages (Bachelor)....253
SWT-SEM-M: Seminar in Software Engineering and Programming Languages (Master)....255
SWT-SWL-B: Software Engineering Lab....257
SYSNAP-OSE-M: Operating Systems Engineering....259
SYSNAP-Project-B: Project Systems Programming....262
SYSNAP-Project-M: Project Systems Programming....264
SYSNAP-SEM-B: Seminar System Software....266
SYSNAP-SEM-M: Seminar System Software....268
SYSNAP-Virt-M: Virtualization....270

VIS-IVVA-M: Advanced Information Visualization and Visual Analytics........ 273
VIS-Proj-B: Bachelor Project Information Visualization........ 275
VIS-Proj-M: Master Project Information Visualization........ 277
VIS-Sem-B: Bachelor Seminar Information Visualization........ 279
VIS-Sem-M: Master Seminar Information Visualization........ 281
xAI-DL-M: Deep Learning........ 283
xAI-MML-B: Mathematics for Machine Learning........ 286
xAI-Proj-B: Bachelor Project Explainable Machine Learning........ 288
xAI-Proj-M: Master Project Explainable Machine Learning........ 290
xAI-Sem-B1: Bachelor Seminar Explainable Machine Learning........ 292
xAI-Sem-M1: Master Seminar Explainable Machine Learning........ 294

Index by areas of study

1) International studies taught in English (on demand) (Bereich)

Find all courses taught in English (on demand) below. Please note: Lecturers will usally ask in the first session whether it should be held in German or English. It is possible, however, they will conduct their session in German. Please don't be afraid to demand continuing in English.

a) Applied Computer Science (Subject Group)

aa) Explainable Machine Learning (Subject)

xAI-DL-M: Deep Learning (6 ECTS, every winter semester).. 283

xAI-MML-B: Mathematics for Machine Learning (6 ECTS, every summer semester)............................ 286

xAI-Proj-B: Bachelor Project Explainable Machine Learning (6 ECTS, every summer semester)........... 288

xAI-Proj-M: Master Project Explainable Machine Learning (6 ECTS, every winter semester).................290

xAI-Sem-B1: Bachelor Seminar Explainable Machine Learning (3 ECTS, every semester)....................292

xAI-Sem-M1: Master Seminar Explainable Machine Learning (3 ECTS, every semester)...................... 294

bb) Computer Graphics and its Foundations (Subject)

CG-ProjCGA-B: Project Computer Graphics (6 ECTS, every summer semester).....................................49

CG-ProjCGA-M: Project Computer Graphics (6 ECTS, every summer semester)................................... 51

CG-ProjVRAR-B: Project Virtual Reality / Augmented Reality (6 ECTS, every winter semester)..............52

CG-ProjVRAR-M: Project Virtual Reality / Augmented Reality (6 ECTS, every winter semester)............. 53

CG-SemCGA-B: Seminar Computer Graphics and Animation (3 ECTS, every summer semester).......... 54

CG-SemVRAR-B: Seminar Virtual Reality / Augmented Reality (3 ECTS, every winter semester)...........55

CG-VRAR-M: Virtual Reality / Augmented Reality (6 ECTS, every summer semester)........................... 56

cc) AI Systems Engineering (Subject)

AISE-ETH: Ethics and Epistemology of AI (6 ECTS, every summer semester).......................................21

AISE-FTAIP-B: Frontier Topics in AI and Philosophy (6 ECTS,).. 24

AISE-PLM-V: Computational Metaphysics -- Mechanizing Principia Logico-Metaphysica (3 ECTS, annually).. 28

AISE-Proj-B: Bachelorprojekt KI-Systementwicklung (6 ECTS, every winter semester)........................... 30

AISE-ProjPrak-UR: Universal Reasoning (in Philosophy, Mathematics and Computer Science) (15 ECTS, every winter semester)..33

AISE-Sem-M: Masterseminar zu KI-Systementwicklung (Oberseminar) (3 ECTS, every semester)......... 35

AISE-SemCP-B: Bachelorseminar Computational Philosophy (3 ECTS, every winter semester)............. 37

AISE-UL: Universal Logic & Universal Reasoning (6 ECTS, every winter semester)................................ 39

dd) Cognitive Systems (Subject)

KogSys-Proj-B: Bachelor Project Cognitive Systems (6 ECTS, every summer semester)...................... 182

KogSys-Sem-B: Bachelor Seminar Cognitive Systems (3 ECTS, every winter semester)...................... 184

ee) Information Visualization (Subject)

VIS-IVVA-M: Advanced Information Visualization and Visual Analytics (6 ECTS, every winter semester).. 273

VIS-Proj-B: Bachelor Project Information Visualization (6 ECTS, every winter semester)...................... 275

VIS-Proj-M: Master Project Information Visualization (6 ECTS,)... 277

VIS-Sem-B: Bachelor Seminar Information Visualization (3 ECTS, every semester)............................. 279

VIS-Sem-M: Master Seminar Information Visualization (3 ECTS, every semester)............................... 281

ff) Multimodal Intelligent Interaction (Subject)

MII-ProjCR-B: Bachelor Project Cognitive Robotics (6 ECTS, every summer semester)........................ 186

MII-ProjCR-M: Master Project Cognitive Robotics (6 ECTS, every summer semester).......................... 187

MII-SemHRI-B: Bachelor Seminar Human-Robot Interaction (3 ECTS, every winter semester)............. 188

MII-SemHRI-M: Master Seminar Human-Robot Interaction (3 ECTS, every winter semester)................ 189

gg) Natural Language Generation and Dialogue Systems (Subject)

DS-ConvAI-M: Advanced Dialogue Systems and Conversational AI (6 ECTS, every summer semester).. 58

DS-Proj-M: Project Dialogue systems (6 ECTS, every semester).. 60

DS-Sem-M: Master Seminar Conversational AI (3 ECTS, every semester)... 62

hh) Human-Computer Interaction (Subject)

HCI-DFM-M: Design and Research Methods of Human-Computer Interaction (6 ECTS, every summer semester).. 107

HCI-DISTP-B: Design of Interactive Systems: Theory and Practice (6 ECTS, every summer semester).. 110

HCI-IS-B: Interactive Systems (6 ECTS, every winter semester)... 112

HCI-KS-B: Cooperative Systems (6 ECTS, every summer semester).. 115

HCI-MCI-M: Human-Computer Interaction (6 ECTS, every winter semester).. 118

HCI-Proj-B: Project Human-Computer Interaction (6 ECTS, every winter semester)............................. 121

HCI-Proj-M: Project Human-Computer Interaction (6 ECTS, every summer semester).......................... 123

HCI-Proj1-M: Research-Project Human-Computer Interaction (15 ECTS, every summer semester)...... 125

HCI-Proj2-M: Research-Project Human-Computer Interaction (15 ECTS, every winter semester)......... 127

HCI-Prop-M: Propaedeutic: Human-Computer-Interaction (3 ECTS, every winter semester)................. 129

HCI-Sem-B: Bachelor-Seminar Human-Computer Interaction (3 ECTS, every summer semester).........131

HCI-Sem-HCC-M: Master-Seminar Human-Centred Computing (3 ECTS, every summer semester).....133

HCI-Sem-M: Master-Seminar Human-Computer Interaction (3 ECTS, every winter semester).............. 135

HCI-US-B: Ubiquitous Systems (6 ECTS, every winter semester)...137

HCI-Usab-M: Usability in Practice (6 ECTS, every summer semester)..140

ii) Fundamentals of Natural Language Processing (Subject)

NLProc-ANLP-M: Applied Natural Language Processing (6 ECTS, every semester)............................ 202

NLProc-ILT-M: Impact of Language Technology (6 ECTS, every winter semester)...............................204

NLProc-PGM4NLP-M: Probabilistic Graphical Models for Natural Language Processing (6 ECTS, every winter semester)...206

NLProc-Sem1-M: Master Seminar Natural Language Processing 1 (3 ECTS, every semester)............. 208

NLProc-Sem2-M: Master Seminar Natural Language Processing 2 (3 ECTS, every semester)............. 210

b) Information Systems (Subject Group)

aa) Information Systems Management (Subject)

ISM-DSI-M: Global Collaboration and Digital Social Innovation (6 ECTS, every winter semester)..........160

bb) Information Systems and Services (Subject)

ISDL-ISS2-M: Optimization of IT-Reliant Processes (6 ECTS, every summer semester)....................... 146

cc) Energy Efficient Systems (Subject)

EESYS-ADAML-M: Applied Data Analytics and Machine Learning in R (6 ECTS, every winter semester)..75

EESYS-BIA-M: Business Intelligence & Analytics (6 ECTS, every winter semester)................................ 78

EESYS-DDS-M: Data-driven Decision Support (6 ECTS, every summer semester)................................81

EESYS-ES-M: Energy Efficient Systems (6 ECTS, every summer semester).. 83

EESYS-P-DINU-M: Project Digital Nudges for Behavior Change in Enterprise Information Systems (6 ECTS, every summer semester)........ 86

dd) AI Engineering in Companies (Subject)

AIC-HYIN-M: Hybrid Intelligence (6 ECTS, every summer semester)........15

AIC-SPRO-M: Research Project: Digital Society and AI-based Systems (6 ECTS, every summer semester)........17

AIC-WPRO-B: Practical Project: Human AI Collaboration (6 ECTS, every winter semester)........19

ee) Social Networks (Subject)

SNA-OSN-M: Project Online Social Networks (6 ECTS, every winter semester)........240

ff) Platform economics (Subject)

ISPL-DIGB-B: Digital Business (6 ECTS, every winter semester)........ 166

ISPL-DPIS-M: Digital Platforms in Industries and Society (6 ECTS, every winter semester)........ 168

ISPL-FIISM-B: Fundamentals of International IS Management (6 ECTS, every summer semester)........ 170

ISPL-MASI-B: Supplier relationships and mergers & acquisitions in the software industry (3 ECTS, every winter semester)........173

ISPL-MDP-M: Managing Digital Platforms (6 ECTS, every summer semester)........ 175

c) Computer Science (Subject Group)

Inf-DM-B: Discrete Modeling (9 ECTS, every winter semester)........ 177

aa) Privacy and Security in Information Systems (Subject)

PSI-AdvaSP-M: Advanced Security and Privacy (6 ECTS, every summer semester)........212

PSI-DiffPriv-M: Introduction to Differential Privacy (6 ECTS, every winter semester)........ 215

PSI-EDS-B: Ethics for the Digital Society (3 ECTS, every winter semester)........217

PSI-IntroSP-B: Introduction to Security and Privacy (6 ECTS, every winter semester)........219

PSI-ProjectCAD-M: Project Complex Attacks and Defenses (9 ECTS, every semester)........ 222

PSI-ProjectPAD: Project Practical Attacks and Defenses (6 ECTS, every semester)........225

PSI-ProjectSP-M: Project Security and Privacy (6 ECTS, every semester)........ 228

PSI-SSSProject-B: Software Systems Science Project: Security and Privacy (12 ECTS, every semester)........230

PSI-Sem-B: Seminar Security and Privacy Foundations (3 ECTS, every semester)........ 232

PSI-Sem-M: Seminar Research Topics in Security and Privacy (3 ECTS, every semester)........ 234

bb) Distributed Systems (Subject)

DSG-IDistrSys-B: Introduction to Distributed Systems (6 ECTS, every summer semester)......................64

cc) Systems Programming (Subject)

SYSNAP-OSE-M: Operating Systems Engineering (6 ECTS, every summer semester)........................ 259

SYSNAP-Project-B: Project Systems Programming (6 ECTS, every semester).................................... 262

SYSNAP-Project-M: Project Systems Programming (6 ECTS, every semester)...................................264

SYSNAP-SEM-B: Seminar System Software (3 ECTS, every semester).. 266

SYSNAP-SEM-M: Seminar System Software (3 ECTS, every semester)...268

SYSNAP-Virt-M: Virtualization (6 ECTS, every winter semester)...270

dd) Foundations of Computer Science (Subject)

GdI-CSNL-M: Computational Semantics of Natural Language (6 ECTS, every summer semester)..........89

GdI-FPRS-M: Functional Programming of Reactive Systems (6 ECTS, every summer semester)........... 91

GdI-GTI-B: Machines and Languages (6 ECTS, every summer semester)... 94

GdI-IFP-M: Introduction to Functional Programming (6 ECTS, every winter semester)........................... 96

GdI-Proj-B: Foundations of Computing Project (6 ECTS, every semester)...100

GdI-Proj-M: Master's Project Theoretical Foundations of Computing (6 ECTS, every semester)............102

GdI-Sem-B: Seminar Foundations of Computing (3 ECTS, winter and summer semester, on demand)..104

GdI-Sem-M: Master's Seminar Theoretical Computer Science (3 ECTS, winter or summer semester, on demand)..105

ee) Software Technologies (Subject)

SWT-ASV-M: Applied Software Verification (6 ECTS, every summer semester)...................................244

SWT-FPS-B: Foundations of Program Semantics (6 ECTS, every winter semester).............................246

SWT-FSE-B: Foundations of Software Engineering (6 ECTS, every summer semester).......................249

SWT-PR1-M: Masters Project in Software Engineering and Programming Languages (6 ECTS, every winter semester)...251

SWT-SEM-B: Seminar in Software Engineering and Programming Languages (Bachelor) (3 ECTS, every summer semester)... 253

SWT-SEM-M: Seminar in Software Engineering and Programming Languages (Master) (3 ECTS, every summer semester)... 255

SWT-SWL-B: Software Engineering Lab (6 ECTS, every winter semester)...257

ff) Data Engineering (Subject)

DT-CPP-B: Introduction into Systems Programming in C++ (6 ECTS, every winter semester)................67

DT-CPP-M: Advanced Systems Programming in C++ (Master) (6 ECTS, every winter semester)........... 68

DT-DB4MLKD-B: Modern Database Systems for Machine Learning and Knowledge Discovery (3 ECTS, winter and summer semester, on demand)..70

DT-DBCPU-M: Database Systems for modern CPU (6 ECTS, every summer semester).........................71

DT-Proj-B: Bachelor Project: Data Engineering (6 ECTS, every semester)...73

DT-Proj-M: Project: Data Engineering (6 ECTS, every semester)... 74

gg) Algorithms and Complexity Theory (Subject)

AlgoK-AK-B: algorithms and complexity (6 ECTS, every summer semester).. 42

AlgoK-Sem-B: Bachelor Seminar Algorithms and Complexity Theory (3 ECTS, winter and summer semester, on demand)..45

AlgoK-Sem-M: Master Seminar Algorithms and Complexity Theory (3 ECTS, winter and summer semester, on demand)..46

AlgoK-TAG: Baumzerlegungen, Algorithmen und Spiele (6 ECTS, every winter semester)......................47

hh) Mobile Software Systems/Mobility (Subject)

MOBI-ADM-M: Advanced Data Management (6 ECTS, every summer semester)................................ 190

MOBI-DSC-M: Data Streams and Complex Event Processing (6 ECTS, every winter semester)...........192

MOBI-PRS-M: Master Project Mobile Software Systems (SoSySc) (9 ECTS, every summer semester)...194

MOBI-Proj-B: Bachelor Project Mobile Software Systems (6 ECTS, every semester)............................196

MOBI-Proj-M: Master Project Mobile Software Systems (6 ECTS, every winter semester).................... 198

MOBI-SEM-B: Bachelor-Seminar Mobile Software Systems (3 ECTS, every winter semester)..............200

MOBI-SEM-M: Master-Seminar Mobile Software Systems (3 ECTS, every winter semester)................201

2) Course language German, exams in English on demand, course material may be available in English (Bereich)

Find all courses taught in German with course material available and exam held in English on demand below. Please notify the lecturer you need the course material/exam in English!

a) Information Systems (Subject Group)

aa) Industrial Information Systems (Subject)

IIS-Sem-B: Bachelor Seminar Industrial Information Systems (3 ECTS, every winter semester)............142

IIS-Sem-M: Master Seminar Industrial Information Systems (3 ECTS, every winter semester).............. 143

bb) Energy Efficient Systems (Subject)

cc) Information Systems and Services (Subject)

ISDL-DEXP-B: Digital Experimentation (6 ECTS, every winter semester)... 144

ISDL-ISS3-M: IT Business Value (6 ECTS, every summer semester)...151

dd) Digital Health (Subject)

ISHANDS-Change-M: Digital Change Management (6 ECTS, every summer semester)....................... 154

ISHANDS-Health-M: Digital Health (6 ECTS, every summer semester)... 157

ee) Information Systems Management (Subject)

ISM-IOM-M: International Outsourcing Management (6 ECTS, every winter semester)......................... 163

ff) Social Networks (Subject)

SNA-ASN-M: Social Network Analysis (6 ECTS, every winter semester)...236

SNA-NET-M: Network Theory (6 ECTS, every summer semester)...238

SNA-WIM-B: Knowledge- and Informationmanagement (6 ECTS, every summer semester)................. 242

b) Computer Science (Subject Group)

aa) Foundations of Computer Science (Subject)

GdI-MTL-B: Modal and Temporal Logic (6 ECTS, every winter semester)... 98

c) Applied Computer Science (Subject Group)

aa) Cognitive Systems (Subject)

KogSys-KI-B: Introduction to Artificial Intelligence (6 ECTS, every summer semester).......................... 179

Module AIC-HYIN-M Hybrid Intelligence *Hybrid Intelligence*		6 ECTS / 180 h
(since SS25) Person responsible for module: Prof. Dr. Milad Mirbabaie		
Contents: This module deepens the theoretical, conceptual, and practical foundations of Hybrid Intelligence. Students acquire comprehensive knowledge about integrating artificial and human intelligence in Hybrid Intelligence systems. Hybrid Intelligence aims to combine human and machine strengths by integrating human capabilities such as creativity, emotional intelligence, or contextual understanding with the computational capabilities of AI, such as data analytics or pattern recognition. This module focuses on theoretical concepts, methodological approaches, and practical applications of Hybrid Intelligence.		
Learning outcomes: The aim of the module is to provide students with in-depth knowledge and skills in the field of Hybrid Intelligence. After completing the module, students should be able to comprehensively understand relevant literature in relation to the interaction between humans and machines in order to be able to analyze and critically evaluate the concept of Hybrid Intelligence.		
Remark: The workload for this module is roughly broken down as follows: • Participation in the input sessions on the basics of Hybrid Intelligence • Self-study and preparation of paper presentations in individual or group work • Completion of in-depth assignments in individual or group work • Preparation of a term paper		
prerequisites for the module: None		
Recommended prior knowledge: None		**Admission requirements:** Successful participation in the exercises.
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Hybrid Intelligence **Mode of Delivery:** Lectures and Practicals **Lecturers:** Prof. Dr. Milad Mirbabaie **Language:** English **Frequency:** every summer semester **Learning outcome:** The aim of the module is to provide students with in-depth knowledge and skills in the field of Hybrid Intelligence. After completing the module, students should be able to comprehensively understand relevant literature in relation to the interaction between humans and machines in order to be able to analyze and critically evaluate the concept of Hybrid Intelligence.	**4,00 Weekly Contact Hours**

Contents: This module deepens the theoretical, conceptual, and practical foundations of Hybrid Intelligence. Students acquire comprehensive knowledge about integrating artificial and human intelligence in Hybrid Intelligence systems. Hybrid Intelligence aims to combine human and machine strengths by integrating human capabilities such as creativity, emotional intelligence, or contextual understanding with the computational capabilities of AI, such as data analytics or pattern recognition. This module focuses on theoretical concepts, methodological approaches, and practical applications of Hybrid Intelligence.	
Examination Coursework Assignment and Colloquium / Duration of Examination: 60 minutes Duration of Coursework: 3 months	

Module AIC-SPRO-M Research Project: Digital Society and AI-based Systems *Forschungsprojekt Digital Society and AI-based Systems*	6 ECTS / 180 h
(since SS25) Person responsible for module: Prof. Dr. Milad Mirbabaie	

Contents:

The course deals with the future of society and the use of artificial intelligence and assistance systems. Relevant topics are explored and reflected on the basis of empirical and theoretical work. The focus is on the question of how society deals with new technologies and the resulting opportunities and risks. Current scientific and socially relevant topics are explained and developments critically reflected on the basis of empirical and theoretical literature.

Learning outcomes:

Students will be able to classify important areas of influence of the digital transformation with a view to society. In addition to the technological and conceptual foundations, ethical aspects are also known and included in the assessment. Students understand the interdisciplinary nature of research and practice, especially with regard to the change in the social status quo through digital technologies, such as artificial intelligence/assistance systems.

Students will be able to assess the overall role of digital technologies in the social context. They are familiar with common methods and technologies and can apply them prototypically. They are familiar with the ethical implications and challenges posed by new technologies and are able to interpret and critically classify empirical and theoretical work in this context. A further qualification feature is that the content covered can be applied to their own questions. To this end, relevant research questions and research gaps can be identified.

prerequisites for the module:

None

Recommended prior knowledge: Previous knowledge of research methods is helpful.		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Forschungsprojekt Digital Society and AI-based Systems **Mode of Delivery:** **Lecturers:** Prof. Dr. Milad Mirbabaie **Language:** English **Frequency:** every summer semester	**4,00 Weekly Contact Hours**
Learning outcome: Students demonstrate the ability to understand key areas of influence of the digital transformation in relation to society. In addition to an understanding of the technological and conceptual foundations, they are also familiar with ethical aspects, which they include in their assessments. Students recognize the interdisciplinary nature of research and practice, especially with regard to the change in the social status quo through digital technologies such as artificial intelligence and assistance systems.	

In addition, students are able to make a comprehensive assessment of the role digital technologies play in the social context. They are familiar with common methods and technologies and can apply them in prototypical form. They are also aware of the ethical implications and challenges associated with new technologies. They are able to interpret and critically analyze empirical and theoretical work in this context. A further qualification feature is their ability to apply the content covered to their own questions by identifying relevant research questions and gaps. **Contents:** The course deals with the future of society and the use of artificial intelligence and assistance systems. Relevant topics are explored and reflected on the basis of empirical and theoretical work. The focus is on the question of how society deals with new technologies and the resulting opportunities and risks. Current scientific and socially relevant topics are explained and developments critically reflected on the basis of empirical and theoretical literature. **Literature:** Further information will be provided in the course.	
Examination Coursework Assignment and Colloquium / Duration of Examination: 60 minutes Duration of Coursework: 3 months	

Module AIC-WPRO-B Practical Project: Human AI Collaboration *Praxisprojekt Human AI Collaboration*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Milad Mirbabaie		
Contents: Im Praxisprojekt Human-AI Collaboration bearbeiten Studierende eine forschungs- oder praxisorientierte Fragestellung in einer Gruppe. Das Ziel der praxisorientierten Wirtschaftsinformatikprojekte ist in der Regel die Lösung eines praxisrelevanten Problems, beispielsweise durch die Erhebung von Anforderungen, Prototyping und Evaluation eines Artefakts. In einem forschungsorientierten Projekt liegt der Fokus darauf, wissenschaftliche Methoden (z. B. Literaturrecherche, Interviews, Experimente, oder Umfragen) zu erlernen und einzusetzen, um wissenschaftliche Erkenntnisse zu gewinnen. Ein wesentlicher Bestandteil des Wirtschaftsinformatikprojekts ist außerdem die Arbeit und Selbstorganisation in der Gruppe und Präsentation der Ergebnisse. Die Leistungserbringung erfolgt über einen Projektbericht.		
Learning outcomes: Ziel des Moduls ist die selbstständige Erarbeitung von Projekten. Hierzu lernen die Studierenden gängige Methoden der Wirtschaftsinformatik kennen, um die Problemstellung in Gruppen zu bearbeiten. Über die fachliche Kompetenz hinaus, erlernen sie auch noch Projektorganisation und -management.		
prerequisites for the module: keine		
Recommended prior knowledge: keine		**Admission requirements:** keine
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Praxisprojekt Human AI Collaboration **Mode of Delivery:** **Lecturers:** Prof. Dr. Milad Mirbabaie **Language:** German **Frequency:** every winter semester	**4,00 Weekly Contact Hours**
Learning outcome: Ziel des Moduls ist die selbstständige Erarbeitung von Projekten. Hierzu lernen die Studierenden gängige Methoden der Wirtschaftsinformatik kennen, um die Problemstellung in Gruppen zu bearbeiten. Über die fachliche Kompetenz hinaus, erlernen sie auch noch Projektorganisation und -management.	
Contents: Im Praxisprojekt Human-AI Collaboration bearbeiten Studierende eine forschungs- oder praxisorientierte Fragestellung in einer Gruppe. Das Ziel der praxisorientierten Wirtschaftsinformatikprojekte ist in der Regel die Lösung eines praxisrelevanten Problems, beispielsweise durch die Erhebung von Anforderungen, Prototyping und Evaluation eines Artefakts. In einem forschungsorientierten Projekt liegt der Fokus darauf, wissenschaftliche Methoden (z. B. Literaturrecherche, Interviews, Experimente, oder Umfragen)	

zu erlernen und einzusetzen, um wissenschaftliche Erkenntnisse zu gewinnen. Ein wesentlicher Bestandteil des Wirtschaftsinformatikprojekts ist außerdem die Arbeit und Selbstorganisation in der Gruppe und Präsentation der Ergebnisse. Die Leistungserbringung erfolgt über einen Projektbericht. **Literature:** Weiterführende Informationen werden in der Veranstaltung bekanntgegeben.	
Examination Coursework Assignment and Colloquium / Duration of Examination: 60 minutes Duration of Coursework: 3 months **prerequisites for module examination:** keine **Description:** Die Leistungserbringung erfolgt über einen Projektbericht.	

Module AISE-ETH Ethics and Epistemology of AI *Ethics and Epistemology of AI*		6 ECTS / 180 h
(since SS22) Person responsible for module: Prof. Dr. Christoph Benzmüller		
Contents: This course takes an innovative and experimental approach to ethics with an interdisciplinary focus enabled by collaboration between the Computer Science, Engineering Science and Philosophy of Technology departments. It involves engaging with the theoretical and practical approaches that address the intersection of ethics and technology, in this case AI.		
Learning outcomes: Students will learn to critically assess the relationship between technology and society and to analyze the interactions between technology and society from an ethical perspective. Furthermore, students will deal with the deconstruction of the concept of neutrality of technology and learn to critically assess it. At the same time, the environment will be taken as a stakeholder in its own right in order to consider the impact of technological applications from a sustainability perspective. The module will provide students with the necessary theoretical foundations stemming from both computer science (in particular AI and digital technologies) and ethics. This knowledge will be put into practice and deepened through case-based projects carried out in interdisciplinary groups. The projects will address the current challenges encountered through the use of AI technologies in different fields of application (e.g., medical, financial, social etc.), as well as discuss different implementations and possible avenues of research that could enable the development of ethically acceptable AI systems. Students will prepare a presentation of their project as well as a scientific poster.		
Remark: The main language of instruction in this course is English. The course is held in collaboration with TU Berlin (group of Prof. Dr. Sabine Ammon)		
prerequisites for the module: keine		
Recommended prior knowledge: Basic knowledge in AI, philosophy or computational humanities.		**Admission requirements:** keine
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Lecture Ethics and Epistemology of AI **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Christoph Benzmüller **Language:** English **Frequency:** every summer semester	**2,00 Weekly Contact Hours**
Learning outcome: Students will learn to critically assess the relationship between technology and society and to analyze the interactions between technology and society from an ethical perspective. Furthermore, students will deal with the deconstruction of the concept of neutrality of technology and learn to critically assess it. At the same time, the environment will be taken as a stakeholder in its own right in	

order to consider the impact of technological applications from a sustainability perspective. The module will provide students with the necessary theoretical foundations stemming from both computer science (in particular AI and digital technologies) and ethics. This knowledge will be put into practice and deepened through case-based projects carried out in interdisciplinary groups. The projects will address the current challenges encountered through the use of AI technologies in different fields of application (e.g., medical, financial, social etc.), as well as discuss different implementations and possible avenues of research that could enable the development of ethically acceptable AI systems. Students will prepare a presentation of their project as well as a scientific poster. **Contents:** This course takes an innovative and experimental approach to ethics with an interdisciplinary focus enabled by collaboration between the Computer Science, Engineering Science and Philosophy of Technology departments. It involves engaging with the theoretical and practical approaches that address the intersection of ethics and technology, in this case AI. **Literature:** selected research papers are announced in lecture course	
2. Lecture Ethics and Epistemology of AI **Mode of Delivery:** Practicals **Lecturers:** Prof. Dr. Christoph Benzmüller **Language:** English **Frequency:** every summer semester **Learning outcome:** Students will learn to critically assess the relationship between technology and society and to analyze the interactions between technology and society from an ethical perspective. Furthermore, students will deal with the deconstruction of the concept of neutrality of technology and learn to critically assess it. At the same time, the environment will be taken as a stakeholder in its own right in order to consider the impact of technological applications from a sustainability perspective. The module will provide students with the necessary theoretical foundations stemming from both computer science (in particular AI and digital technologies) and ethics. This knowledge will be put into practice and deepened through case-based projects carried out in interdisciplinary groups. The projects will address the current challenges encountered through the use of AI technologies in different fields of application (e.g., medical, financial, social etc.), as well as discuss different implementations and possible avenues of research that could enable the development of ethically acceptable AI systems. Students will prepare a presentation of their project as well as a scientific poster. **Contents:** This course takes an innovative and experimental approach to ethics with an interdisciplinary focus enabled by collaboration between the Computer Science, Engineering Science and Philosophy of Technology departments. It	**2,00 Weekly Contact Hours**

involves engaging with the theoretical and practical approaches that address the intersection of ethics and technology, in this case AI. **Literature:** selected research papers are announced in lecture course	

Examination Portfolio **Description:** The module examination consists of five parts: • Text-Mind-Map (15%): Reading and presentation of a text + summary of contents through a mind-map (1 page) • Debate Moderation (10%): Moderation of a debate • Interim Presentation (15%): Presentation (with slides) of interim results and future work planned to achieve the project • Final Presentation (25%): 20 min Presentation (with slides/poster) + 20 min Q&A • Final Deliverable (35%): Depending on the project, can take the form of a short guide, website, computer program, or audio/video material + documentation of the project	

Module AISE-FTAIP-B Frontier Topics in AI and Philosophy *Frontier Topics in AI and Philosophy*	6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Christoph Benzmüller	

Contents:

The course explores state-of-the-art topics at the frontier between philosophy and Artificial Intelligence, including:

A. Introduction to AI and Philosophy: This is an overview of fundamental concepts in artificial intelligence and the philosophical questions that have accompanied its development. This includes e.g. questions about the extent and limits of considering human thought computable.

B. Critical Reflections on Ethics and AI: This topic refers to the critical examination of current ethical considerations inherent in the design, development, and deployment of AI systems. The focus is on challenging and questioning current investigations on XAI, transparency of AI, algorithmic bias, and the responsibility of AI developers towards society.

C. Consciousness and Artificial Minds: This relates to the research program connecting artificial and human neural structures. It includes not only current parallelism between AI and neuroscience (e.g. the understanding of human brain models as vector space), but also what AI advancements can tell us about consciousness and the mind. Discussions could also cover the possibility of machine consciousness and the issue of machine creativity.

D. Philosophy of Information: This topic delves into the philosophy of information as it relates to AI, including the relationship between entropy and information, the ontology of information, the ethics of information, and how AI reshapes these philosophical issues.

E. AI, Society, and the Future: This includes the analysis of the broader societal impacts of AI, such as privacy, surveillance, labor rights, and the future of human-machine coexistence. This also includes specific case studies such as AI in healthcare, autonomous vehicles, natural language processing, etc.

All in all, the course aims at bringing together insights from Ai research and philosophy to foster a holistic understanding of AI's multifaceted impact on modern life and future directions in human cognition and social organization.

Learning outcomes:

For computer science students attending the course “Frontier Topics in AI and Philosophy,” the learning objectives are designed to bridge the gap between technical AI competencies and philosophical understanding, fostering a comprehensive, interdisciplinary skill set. Here are the key learning objectives and skills:

1. Understanding of AI Foundations and Philosophical Implications: Students will gain a solid grounding in the fundamental concepts of artificial intelligence, alongside an understanding of the philosophical questions that accompany AI’s development.

2. Critical Analysis: Students will develop the ability to critically examine the ethical considerations in AI’s design, development, and deployment.

3. Multidisciplinary Insights: Students will acquire knowledge on the intersections between AI and the philosophical approach to neuroscience and human cognition concerning consciousness and understanding between human and machine.

4. Societal impact: As potential future handler and programmer of AI systems, the course students will learn to understand the broader societal impacts of AI systems, with focuses on the evaluation of specific case studies to understand the practical applications and ethical dilemmas of AI technologies.

5. Critical Thinking and Innovation: Students will acquire a holistic understanding of AI's multifaceted impact on modern life, human cognition, and social organization. Students will be encouraged to think beyond conventional boundaries to cultivate a well-rounded perspective on AI's role in society and future directions.

6. Interdisciplinary Communication: In light of the interdisciplinary nature of AI research, students will acquire effective communication skills that enable the articulation of complex ideas and debates in AI to diverse audiences, including technical and non-technical stakeholders.

prerequisites for the module:
none

Recommended prior knowledge: none		**Admission requirements:** none
Frequency: 1	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Tutorial: Introduction to Formal Languages: Applications and Philosophical Questions **Mode of Delivery:** Practicals **Language:** German/English **Frequency:** every winter semester **Learning outcome:** Students will be introduced to the fundamentals of formal languages, from basic principles to more advanced applications. This includes propositional logic, first order logic, modal logic, and lambda calculus (in the tutorials). Learning the syntax and semantics of such formal languages is crucial for understanding the computational processes and algorithms that underpin computer science.	**2,00 Weekly Contact Hours**

The course also illuminates the philosophical aspects and challenges associated with formal languages. This includes questions about the limits of formal languages (undecidability, incompleteness), the impact of this limit on the computability of human thinking, semantic paradoxes, and their resolution. Engaging with these conceptual foundations and implications of formal languages encourages critical thinking and a deeper understanding of the theoretical underpinnings of computer science.

Beyond theoretical knowledge, the course emphasizes the practical application of formal languages. Students are expected to develop the ability to utilize formal languages in relevant contexts, recognizing their potential for automation and data processing. This skill set is essential for the development, analysis, and optimization of algorithms and software.

Contents:
Exercises complementing the lecture content as described above.

Module Units

Vorlesung AISE-FTAIP Frontier Topics in AI and Philosophy
Mode of Delivery: Lectures
Language: German/English
Frequency: every winter semester

2,00 Weekly Contact Hours

Learning outcome:
Students will be introduced to the fundamentals of formal languages, from basic principles to more advanced applications. This includes propositional logic, first order logic, modal logic, and lambda calculus (in the tutorials). Learning the syntax and semantics of such formal languages is crucial for understanding the computational processes and algorithms that underpin computer science.

The course also illuminates the philosophical aspects and challenges associated with formal languages. This includes questions about the limits of formal languages (undecidability, incompleteness), the impact of this limit on the computability of human thinking, semantic paradoxes, and their resolution. Engaging with these conceptual foundations and implications of formal languages encourages critical thinking and a deeper understanding of the theoretical underpinnings of computer science.

Beyond theoretical knowledge, the course emphasizes the practical application of formal languages. Students are expected to develop the ability to utilize formal languages in relevant contexts, recognizing their potential for automation and data processing. This skill set is essential for the development, analysis, and optimization of algorithms and software.

Contents:

This lecture offers an accessible, step-by-step introduction to formal languages, requiring no prior knowledge or prerequisites. It is designed to equip students with fundamental skills in formal languages as well as an understanding of their role in philosophy, computer science, and linguistics. Formal languages are crucial to the efficient and precise communication of information, offering agility and clarity that surpass natural language, and allowing for information automation in computer. This makes the mastery of formal languages not just an intellectual pursuit but an important practical skill for future working philosophers, computer scientists, and linguists. In addition, formal languages are at the center of some of the most puzzling philosophical questions, for example about the limits of cognition, semantic paradoxes, or the existence of abstract objects. Complementing the lecture is the seminar Language and Beyond: Philosophy, Computer Science, Linguistics; it provides reading materials, exercises, and examples on the topics of the course. The seminar is optional, but recommended.	
Examination Written examination / Duration of Examination: 90 minutes	

Module AISE-PLM-V Computational Metaphysics -- Mechanizing Principia Logico-Metaphysica *Computational Metaphysics -- Mechanizing Principia Logico-Metaphysica*		3 ECTS / 90 h
(since SS23) Person responsible for module: Prof. Dr. Christoph Benzmüller further responsible : Kirchner, Daniel, Dr.; Vestrucci, Andrea, Prof. Dr.		
Contents: In this lecture course we will study foundational theories in metaphysics (with a focus on Edward Zalta's Principia Logico-Metaphysica) and discuss/explore their mechanisation and assessment with modern proof assistant systems.		
Learning outcomes: Acquisition of basic knowledge on the foundations of metaphysics, and acqusition of basic knowledge on the mechanisation of such theories in modern proof assistant systems.		
Remark: Will be offered (ideally yearly) as block course in collaboration with Edward Zalta, PhD, Stanford University		
prerequisites for the module: none		
Recommended prior knowledge: Grundlagenkenntnisse in Logik und Metaphysik sind empfohlen.		**Admission requirements:** none
Frequency: annually	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Computational Metaphysics -- Mechanizing Principia Logico-Metaphysica **Language:** English **Frequency:** every summer semester	**2,00 Weekly Contact Hours**
Learning outcome: Acquisition of basic knowledge on the foundations of metaphysics, and acqusition of basic knowledge on the mechanisation of such theories in modern proof assistant systems.	
Contents: In this lecture course we will study foundational theories in metaphysics (with a focus on Edward Zalta's Principia Logico-Metaphysica) and discuss/explore their mechanisation and assessment with modern proof assistant systems.	
Literature: E. N. Zalta. *Abstract Objects: An Introduction to Axiomatic Metaphysics*. D. Reidel, 1983. ISBN: 9789027714749. E. N. Zalta. *Intensional Logic and the Metaphysics of Intentionality*. MIT Press, 1988. ISBN: 9780262240277. E. N. Zalta. Principia Logico-Metaphysica. https:/ /mally.stanford.edu / principia.pdf. [accessed: January 30, 2023].	

E. N. Zalta. The Theory of Abstract Objects. https://mally.stanford.edu/theory.html. [accessed: January 30, 2023]. D. Kirchner. “Abstract Object Theory”. In: *Archive of Formal Proofs* (Nov. 2022). https://isa-afp.org/entries/AOT. html, Formal proof development. ISSN: 2150-914x. D. Kirchner. “Computer-Verified Foundations of Metaphysics and an Ontology of Natural Numbers in Isabelle/HOL”. PhD thesis, FU Berlin, 2022. https://refubium.fu-berlin.de/handle/fub188/35426 D. Kirchner, C. Benzmüller, and E. N. Zalta. “Computer Science and Metaphysics: A Cross-Fertilization”. In: *Open Philosophy* 2.1 (2019). Ed. by P. Grim, pp. 230–251. DOI: 10.1515/opphil-2019-0015. D. Kirchner, C. Benzmüller, and E. N. Zalta. “Mechanizing Principia Logico-Metaphysica in Functional Type Theory”. In: *Review of Symbolic Logic* 13.1 (2020), pp. 206–218. DOI: 10.1017/S1755020319000297.	

Examination Oral examination / Duration of Examination: 30 minutes	

Module AISE-Proj-B Bachelorprojekt KI-Systementwicklung *Bachelorprojekt KI-Systementwicklung*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Christoph Benzmüller further responsible : Dr. Martin Aleksandrov (FU Berlin)		
Contents: Students will work on a project from across the spectrum of interests of the AISE research group. These research activities lie at the intersection of artificial intelligence, philosophy, mathematics, computer science, and natural language and cover topics such as: • mechanisation of normative reasoning and explanation in computers to develop trusted AI systems • hybrid AI systems: automated reasoning, machine learning and agent-based architectures • AI & ethics, AI & law • rational argumentation • universal logical reasoning • logico-pluralistic knowledge representation and reasoning methodologies and infrastructures • applications: e.g. in computational metaphysics (e.g., Gödel's ontological argument), machine ethics, mathematical foundations (e.g., category theory) • automated theorem proving (e.g. Leo theorem provers) and model finding • interactive/automated theorem proving in research and education		
Learning outcomes: Building on knowledge and skills acquired in prior lectures of the AISE group, small research projects will be defined and implemented, often in group work. In the process, skills in formal modelling and systems development are developed as well as competencies in project implementation and group work.		
Remark: The main language of instruction in this course is English. The entire course will meet once per two weeks for at least 4h. The projects are additionally accompanied by supervised meetings on an individual basis with each student or student group to discuss project-specific details.		
prerequisites for the module: keine		
Recommended prior knowledge: Basic knowledge on AI, logic, theoretical computer science and mathematics; background in theoretical philosophy may also be useful.		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Bachelorprojekt KI-Systementwicklung: Ethics of Intelligent Vehicles **Mode of Delivery:** **Lecturers:** Prof. Dr. Christoph Benzmüller **Language:** German	**4,00 Weekly Contact Hours**

Frequency: every winter semester

Learning outcome:
On successful completion, students will be able to

- discuss challenges (including, ethical aspects) in the development of intelligent systems
- describe and design (efficient) algorithms
- write a scientific report/paper
- review a scientific report/paper
- develop critical thinking

Contents:
The bachelor project addresses problems at the interface of artificial intelligence, social choice theory, intelligent vehicles, and ethics. The course gives to each student the opportunity to develop a state-of-the-art practical research project in one of (but not limited to) the following topics:

- Privacy concerns around intelligent vehicles
- Bias concerns around intelligent vehicles
- Fairness concerns around intelligent vehicles
- Algorithm desing for intelligent vehicles
- Data design for intelligent vehicles
- Applications for intelligent vehicles

Each student in the course will receive the following benefits:

- an interesting research project
- an individual supervision on their project
- a constructive feedback on their progress
- an opportunity to co-author a scientific paper
- an exposure to state-of-the-art research

The project is related to DFG project -http://www.mi.fu-berlin.de/inf/groups/ag-ki/Projects/Fairness-and-Efficiency/index.html

Note on Programming Skills: Some of the projects in the course may require completing a simple experiment for which basic programming skills are required. The student could use any coding language to run the experiment. Although their programming skills will not be evaluated, their results of the experiments will be evaluated.

Literature:
to be announced in lecture course

Examination
Coursework Assignment and Colloquium, project report, a review and a presentation (all in English) / Duration of Coursework: 4 months
prerequisites for module examination:
Continuous attendance in the seminar sessions is mandatory, cf. §9 (10) APO.
Description:

The module examination consists of three parts, a project report, a review and a presentation (all in English). Each participant prepares a manuscript of their project (e.g. 10 pages) during the semester and a review of a fellow student’s manuscript (e.g. 2 page, 60 min) during the final part of the portfolio. The purpose of the presentation (max. 30 min) is to evaluate the proficiency of the student of their project, the significance and contribution of their results for the studied problem and the future directions that arise from their results.	

Module AISE-ProjPrak-UR Universal Reasoning (in Philosophy, Mathematics and Computer Science) *Universal Reasoning (in Philosophy, Mathematics and Computer Science)*		15 ECTS / 450 h
(since WS22/23) Person responsible for module: Prof. Dr. Christoph Benzmüller further responsible : David Fuenmayor, Prof. Dr. Andrea Vestrucci		
Contents: In this internship, students work on changing project topics related to the content of AISE courses. As a rule, aspects of several courses of the AISE group are relevant, so that teams with students who have attended different courses complement each other well. The tasks worked on in a project internship go well beyond the scope of a normal exercise task and are worked on in groups. The result is documented and presented in a final presentation.		
Learning outcomes: On successful completion, students will have • produced a system implementation, or a larger piece of formalised knowledge, in an application area as relevant to the AISE group • learned to discuss and assess challenges (including, ethical aspects) in the development of intelligent systems • learned to write a scientific report/paper of publishable quality (in fact, ideally the project report will lead to publications) • learned to work and interact in small research teams • developed improved critical thinking competence		
prerequisites for the module: keine		
Recommended prior knowledge: Successful participation in the course AISE-UL: Universal Logic & Universal Reasoning or another course of the AISE group (depending on the special nature of the intended project work).		**Admission requirements:** keine
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester Semester

Module Units	
Universal Reasoning (in Philosophy, Mathematics and Computer Science) **Lecturers:** Prof. Dr. Christoph Benzmüller **Language:** English **Frequency:** every winter semester **Learning outcome:** On successful completion, students will have • produced a system implementation, or a larger piece of formalised knowledge, in an application area as relevant to the AISE group • learned to discuss and assess challenges (including, ethical aspects) in the development of intelligent systems	**6,00 Weekly Contact Hours**

• learned to write a scientific report/paper of publishable quality (in fact, ideally the project report will lead to publications) • learned to work and interact in small research teams • developed improved critical thinking competence	
Contents: In this internship, students work on changing project topics related to the content of AISE courses. As a rule, aspects of several courses of the AISE group are relevant, so that teams with students who have attended different courses complement each other well. The tasks worked on in a project internship go well beyond the scope of a normal exercise task and are worked on in groups. The result is documented and presented in a final presentation.	
Literature: will be announced project specific	

Examination No type selected	

Module AISE-Sem-M Masterseminar zu KI-Systementwicklung (Oberseminar) *Masterseminar zu KI-Systementwicklung (Oberseminar)*	3 ECTS / 90 h

(since SS22)
Person responsible for module: Prof. Dr. Christoph Benzmüller

Contents:

This seminar covers selected topics from across the spectrum of interests of the AISE research group. These research activities lie at the intersection of artificial intelligence, philosophy, mathematics, computer science, and natural language and cover topics such as:

- mechanisation of normative reasoning and explanation in computers to develop trusted AI systems
- hybrid AI systems: automated reasoning, machine learning and agent-based architectures
- AI & ethics, AI & law
- rational argumentation
- universal logical reasoning
- logico-pluralistic knowledge representation and reasoning methodologis and infrastructures
- applications: e.g. in computational metaphysics (e.g., Gödel's ontological argument), machine ethics, mathematical foundations (e.g., category theory)
- automated theorem proving (e.g. Leo theorem provers) and model finding
- interactive/automated theorem proving in research and education

Learning outcomes:

Participating students will be introduced to current research questions and papers from the AISE group's spectrum of interest. Students will explore, prepare and present a selected topic and acquire in depth knowledge about the involved research questions and challenges. Ideally, this work will lead to a subsequent topic for a thesis project. Presentations of research topics related to a running thesis project are also welcome. Students will learn to assess and review research papers and to prepare and present own papers.

Remark:

The main language of instruction in this course is English.

In addition to the contributions by participating students there will presentations by PhD students and guest researchers.

prerequisites for the module:

keine

Recommended prior knowledge: Basic knowledge on AI, logic, theoretical computer science and mathematics; background in theoretical philosophy may also be useful. Ideally participants have attended at least one prior course of the AISE group.		**Admission requirements:** ECTS-Bedingungen de
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester Semester

Module Units	
AISE-Sem-M: Masterseminar zu KI-Systementwicklung (Oberseminar) **Mode of Delivery:** Seminar	**2,00 Weekly Contact Hours**

Lecturers: Prof. Dr. Christoph Benzmüller
Language: English
Frequency: every semester

Learning outcome:
Participating students will be introduced to current research questions and papers from the AISE group's spectrum of interest. Students will explore, prepare and present a selected topic and acquire in depth knowledge about the involved research questions and challenges. Ideally, this work will lead to a subsequent topic for a thesis project. Presentations of research topics related to a running thesis project are also welcome. Students will learn to assess and review research papers and to prepare and present own papers.

Contents:
This seminar covers selected topics from across the spectrum of interests of the AISE research group. These research activities lie at the intersection of artificial intelligence, philosophy, mathematics, computer science, and natural language and cover topics such as:

- mechanisation of normative reasoning and explanation in computers to develop trusted AI systems
- hybrid AI systems: automated reasoning, machine learning and agent-based architectures
- AI & ethics, AI & law
- rational argumentation
- universal logical reasoning
- logico-pluralistic knowledge representation and reasoning methodologis and infrastructures
- applications: e.g. in computational metaphysics (e.g., Gödel's ontological argument), machine ethics, mathematical foundations (e.g., category theory)
- automated theorem proving (e.g. Leo theorem provers) and model finding
- interactive/automated theorem proving in research and education

Literature:
to be announced in lecture course

Examination
Internship report / Duration of Examination: 30 minutes
Duration of Coursework: 3 months
prerequisites for module examination:
Continuous attendance in the seminar sessions is mandatory, cf. §9 (10) APO.
Description:
The module examination consists of two parts, a seminar presentation (in English) and a term paper (in English).

Module AISE-SemCP-B Bachelorseminar Computational Philosophy *Bachelorseminar Computational Philosophy*		3 ECTS / 90 h
(since WS24/25) Person responsible for module: Prof. Dr. Christoph Benzmüller further responsible : Prof. Dr. Andrea Vestrucci		
Contents: Gottfried Wilhelm Leibniz had a vision: human thoughts made computable. What is real, what is good, what is beautiful, what is personal identity… all facets of human thinking treated and organised as elements of calculation. This vision had a tremendous multi-part impact which the seminar shall follow: It fostered the development of machines to calculate (“ordinateur”, the French word for “computer,” is what makes order out of chaos); It influenced the so-called analytical approach in philosophy, treating propositions formally; And it established the basis for the science “prior to all others” (K. Gödel), i.e., mathematical logic. This seminar in Computational Philosophy will embrace these three aspects. It will study how, and how far, thinking and algorithm are one thing, and can impact each other. It will ask why Leibniz’s vision has not become reality: What are the computational limits of human thought? What are the (philosophical) limits of computation? And, more importantly, what is left to do? What are the future directions on the path of making our thinking computable, and a machine thinking?		
Learning outcomes: Via the application of AI programs, we will explore the above questions and try to formulate our answers. We will, for instance, discuss current interpretations of AI limits; we will deepen the relationship between Gödel’s incompleteness theorems and Turing’s halting problem; we will explore metaphysical arguments, belief changes, and ethical problems in an automated reasoning environment.		
Remark: The main language of instruction in this course is English.		
prerequisites for the module: Basic knowledge on AI, theoretical computer science and cognitive science; some background in theoretical philosophy is also useful.		
Recommended prior knowledge: Basic knowledge on AI, theoretical computer science and cognitive science; some background in theoretical philosophy is also useful.		**Admission requirements:** keine
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Bachelorseminar Computational Philosophy **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Christoph Benzmüller **Language:** English **Frequency:** every winter semester **Learning outcome:** Via the application of AI programs, we will explore the above questions and try to formulate our answers. We will, for instance, discuss current interpretations of AI limits; we will deepen the relationship between Gödel’s incompleteness theorems	**2,00 Weekly Contact Hours**

and Turing's halting problem; we will explore metaphysical arguments, belief changes, and ethical problems in an automated reasoning environment. **Contents:** Gottfried Wilhelm Leibniz had a vision: human thoughts made computable. What is real, what is good, what is beautiful, what is personal identity… all facets of human thinking treated and organised as elements of calculation. This vision had a tremendous multi-part impact which the seminar shall follow: It fostered the development of machines to calculate ("ordinateur", the French word for "computer," is what makes order out of chaos); It influenced the so-called analytical approach in philosophy, treating propositions formally; And it established the basis for the science "prior to all others" (K. Gödel), i.e., mathematical logic. This seminar in Computational Philosophy will embrace these three aspects. It will study how, and how far, thinking and algorithm are one thing, and can impact each other. It will ask why Leibniz's vision has not become reality: What are the computational limits of human thought? What are the (philosophical) limits of computation? And, more importantly, what is left to do? What are the future directions on the path of making our thinking computable, and a machine thinking? **Literature:** to be announced in lecture course	
Examination Coursework Assignment with presentation / Duration of Examination: 30 minutes Duration of Coursework: 3 months **prerequisites for module examination:** Continuous attendance in the seminar sessions is mandatory, cf. §9 (10) APO. **Description:** The module examination consists of two parts, a term paper (in English) and a talk (in English).	

Module AISE-UL Universal Logic & Universal Reasoning *Universelle Logik & Universelles Schließen*	6 ECTS / 180 h

(since WS22/23)
Person responsible for module: Prof. Dr. Christoph Benzmüller

Contents:
Knowledge representation and reasoning applications in computer science, AI, philosophy and math typically employ very different logic formalisms. Instead of a "single logic that serves it all" (as envisioned already by Leibniz) an entire "logic zoo" has been developed, in particular, during the last century. Logics in this zoo, e.g., include modal logics, conditional logics, deontic logics, multi-valued logics, temporal logics, dynamic logics, hybrid logics, etc. In this lecture course we will introduce, discuss and apply a meta logical approach to universal logical reasoning that addresses this logical pluralism. The core message is this: While it might not be possible to come up with a universal object logic as envisioned by Leibniz, it might in fact be possible to have a universal meta logic in which we can semantically model, analyse and apply various species from the logic zoo. Classical higher order logic (HOL) appears particularly suited to serve as such a universal meta logic, and existing reasoning tools for HOL can fruitfully be reused and applied in this context.

Learning outcomes:
The participants of this course will, in combination with a hands-on introduction to Isabelle/HOL, learn about HOL, about semantical embeddings (SSE technique) of non-classical logics in HOL, and about proof automation of these logics in Isabelle/HOL. They will conduct practical exercises regarding the application of the SSE technique in philosophy, mathematics or artificial intelligence, including, normative reasoning and machine ethics.

Remark:
The main language of instruction in this course is English.
The overall workload of 180h for this module consists of:

- weekly classes: 22h
- tutorials: 8h
- Work on assignment: 90h
- Literature study 40h
- preparation for and time of the final exam: 20h

prerequisites for the module:
none

Recommended prior knowledge: Basic knowledge about classical and non-classical logics, theoretical computer science.		**Admission requirements:** non
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester Semester

Module Units	
AISE-UL: Universal Logic & Universal Reasoning (Universelle Logik & Universelles Schließen) **Mode of Delivery:** Lectures and Practicals **Lecturers:** Prof. Dr. Christoph Benzmüller	**2,00 Weekly Contact Hours**

Language: English **Frequency:** every winter semester **Learning outcome:** The participants of this course will, in combination with a hands-on introduction to Isabelle/HOL, learn about HOL, about semantical embeddings (SSE technique) of non-classical logics in HOL, and about proof automation of these logics in Isabelle/HOL. They will conduct practical exercises regarding the application of the SSE technique in philosophy, mathematics or artificial intelligence, including, normative reasoning and machine ethics. **Contents:** Introduction to and discussion of tools and practical issues closely related to the topics discussed in the lecture as well as solutions of problems that come up during working on the practical assignment. **Literature:** will be announced in lecture course	
Examination Written examination, AISE-UL: Universal Logic & Universal Reasoning (Universelle Logik & Universelles Schließen) **Description:** Oral examination concerning the topics discussed in the lecture, exercises and assignment. Students may choose English or German as the language for the written assignment and oral examination. Examinations will take at the end of the summer term or at the beginning of the winter term (students may choose one of them). Students are assumed to work on an advanced modelling assignment ('schriftliche Hausarbeit') during the semester that is introduced at the beginning of the semester and uses the most important technologies (such as the See technique) discussed during the semester. **Note:** Without working on the modelling assignment over the term students may run into problems during their oral examination (Kolloquium) as we discuss questions concerning topics from the lectures as well as from the assignment; questions about the assignment are based on the assignment solution modelled by the students.	

Module Units	
AISE-UL: Universal Logic & Universal Reasoning (Universelle Logik & Universelles Schließen) **Mode of Delivery:** Practicals **Lecturers:** Prof. Dr. Christoph Benzmüller **Language:** English **Frequency:** every winter semester **Learning outcome:** The participants of this course will, in combination with a hands-on introduction to Isabelle/HOL, learn about HOL, about semantical embeddings (SSE technique) of non-classical logics in HOL, and about proof automation of these logics in Isabelle/HOL. They will conduct practical exercises regarding the application of	**2,00 Weekly Contact Hours**

the SSE technique in philosophy, mathematics or artificial intelligence, including, normative reasoning and machine ethics.	
Contents: Knowledge representation and reasoning applications in computer science, AI, philosophy and math typically employ very different logic formalisms. Instead of a "single logic that serves it all" (as envisioned already by Leibniz) an entire "logic zoo" has been developed, in particular, during the last century. Logics in this zoo, e.g., include modal logics, conditional logics, deontic logics, multi-valued logics, temporal logics, dynamic logics, hybrid logics, etc. In this lecture course we will introduce, discuss and apply a meta logical approach to universal logical reasoning that addresses this logical pluralism. The core message is this: While it might not be possible to come up with a universal object logic as envisioned by Leibniz, it might in fact be possible to have a universal meta logic in which we can semantically model, analyse and apply various species from the logic zoo. Classical higher order logic (HOL) appears particularly suited to serve as such a universal meta logic, and existing reasoning tools for HOL can fruitfully be reused and applied in this context.	
Literature: will be announced in lecture course	

Module AlgoK-AK-B algorithms and complexity *Algorithmen und Komplexität*	6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Isolde Adler	
Contents: Algorithms and problem solving lie at the heart of computer science. Given an algorithmic problem, such as the Traveling Salesperson Problem, how can we design an efficient algorithm? Once we found an algorithm that solves the problem correctly, can we be sure that the resources, such as running time, storage space (and related: energy), required by this algorithm are really necessary for solving the problem? Perhaps we can do better?	
Learning outcomes: Demonstrate an understanding of what constitutes an efficient and an inefficient solution to a computational problem, - Analyse the efficiency of algorithms, - Evaluate and justify appropriate ways to provide efficient solutions for computational problems, - Identify and apply different design principles in the design of algorithms, - Describe efficient algorithms for a range of computational problems, along with their computational complexity, - Describe the use of complexity classes and the relations between them, - Articulate the key concepts and critically evaluate approaches in a clear and rigorous manner, - Appreciate and understand in-depth the role of proofs in the area of algorithm design, - Recognise how the methods learned can be extended and used to solve other problems.	
prerequisites for the module: Keine	
Recommended prior knowledge: Algorithms and data structures, basic knowledge of computability theory, proof techniques. Good English language skills.	**Admission requirements:** none

Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
AlgoK-AK-B (Algorithmen und Komplexität) **Mode of Delivery:** Lectures and Practicals **Language:** English/German **Frequency:** every summer semester **Learning outcome:** Demonstrate an understanding of what constitutes an efficient and an inefficient solution to a computational problem, - Analyse the efficiency of algorithms, - Evaluate and justify appropriate ways to provide efficient solutions for computational problems, - Identify and apply different design principles in the design of algorithms, - Describe efficient algorithms for a range of computational problems, along with their computational complexity, - Describe the use of complexity classes and the relations between them, - Articulate the key concepts and critically evaluate approaches in a clear and rigorous manner, - Appreciate and understand in-depth the role of proofs in the area of algorithm design, - Recognise how the methods learned can be extended and used to solve other problems. **Contents:** Algorithms and problem solving lie at the heart of computer science. Given an algorithmic problem, such as the Traveling Salesperson Problem, how can we design an efficient algorithm? Once we found an algorithm that solves the problem correctly, can we be sure that the resources, such as running time, storage space (and related: energy), required by this algorithm are really necessary for solving the problem? Perhaps we can do better?	**2,00 Weekly Contact Hours**

Examination Oral examination **Description:** Die Prüfungsdauer wird in der ersten LV bekannt gegeben	

Module AlgoK-Sem-B Bachelor Seminar Algorithms and Complexity Theory *Bachelorseminar Algorithmen und Komplexitätstheorie*		3 ECTS / 90 h
(since WS22/23) Person responsible for module: Prof. Dr. Isolde Adler		
Contents: Im Seminarmodul werden wechselnde Themen im Bereich der Algorithmen und Komplexitätstheorie angeboten.		
Learning outcomes: Fähigkeit zur selbständigen Erarbeitung von Inhalten aus der aktuellen wissenschaftlichen Literatur; Fähigkeit, komplexe Problemlösungsansätze schriftlich und mündlich zu vermitteln. Förderung der wissenschaftliche Neugier und die Ausbildung einer selbstbewussten und forschenden Einstellung zur Technik.		
prerequisites for the module: none		
Recommended prior knowledge: Grundlagen der Theoretischen Informatik, Mathematik für Informatik 1, Algorithmen und Datenstrukturen, gute Englischkenntnisse		**Admission requirements:** none
Frequency: winter and summer semester, on demand	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Bachelorseminar Algorithmen und Komplexitätstheorie **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Isolde Adler **Language:** German/English **Frequency:** winter and summer semester, on demand **Contents:** Das AlgoK-Seminar wird zu semesterweise wechselnden Themen angeboten. Die Lehrsprache wird in der ersten Lehrveranstaltung bekanntgegeben. **Literature:** Literatur wird bei Ankündigung bzw. zu Beginn des Seminars bekanntgegeben.	**2,00 Weekly Contact Hours**

Examination Internship report / Duration of Examination: 30 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regelmäßige Teilnahme an den Terminen der Lehrveranstaltungen. **Description:** Die Prüfungssprache wird in der ersten Lehrveranstaltung bekanntgegeben.	

Module AlgoK-Sem-M Master Seminar Algorithms and Complexity Theory *Masterseminar Algorithmen und Komplexitätstheorie*		3 ECTS / 90 h
Person responsible for module: Prof. Dr. Isolde Adler		
Contents: Selected topics in the area of Algorithms and Complexity Theory.		
Learning outcomes: Ability to develop problem solutions from independent research into the current academic literature, specifically with focus on mathematical tools; Ability to communicate complex problem solving approaches orally and in writing. Promotion of scientific curiosity and the formation of a self-confident attitude towards research and problem solving.		
prerequisites for the module: none		
Recommended prior knowledge: Discrete mathematics, in particular graph theory; mathematical proof techniques; algorithms and data structures; elementary logic and algebra; LaTeX. English language skills at level B2 (UniCert II) or above.		**Admission requirements:** none
Frequency: winter and summer semester, on demand	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Master Seminar Algorithms and Complexity Theory **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Isolde Adler **Language:** English/German **Frequency:** winter and summer semester, on demand **Contents:** Selected topics in the area of Algorithms and Complexity Theory are presented by the participants. The module will be taught in English or German. English is the default language. **Literature:** Relevant literature will be communicated at the beginning of the semester and during the first sessions.	**2,00 Weekly Contact Hours**

Examination Internship report / Duration of Examination: 30 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regular participation at the seminar. **Description:** Presentation (30 minutes) and a written report (4 months).	

Module AlgoK-TAG Baumzerlegungen, Algorithmen und Spiele *Tree decompositions, algorithms and games*	6 ECTS / 180 h
(since WS23/24) Person responsible for module: Prof. Dr. Isolde Adler	

Contents:

Many classical algorithmic problems on graphs are hard, e.g. NP-hard, in general. However, they lie at the core of many applications, so they need to be solved in practice. These problems include the famous Graph Colouring Problem, and problems such as Hamiltonian Cycle, Independent Set, Dominating Set, Vertex Cover and many more.
Ideally, we would like to solve these problems exactly and efficiently.
Indeed, many problems become solvable in linear time if we only allow trees as inputs. This observation is the starting point of the module. We then identify more general classes of input graphs that allow solving many problems efficiently.
For this we make use of so-called tree decompositions of graphs. Tree decompositions allow us to obtain "tree like" graphs that are more general than trees but maintain the favourable algorithmic properties of trees.
In the first part of the module we study tree decompositions via a cops-and-robber game played on graphs, where the winning strategies for the cops yield the desired decompositions. We then develop algorithms for tree decompositions and algorithms to solve problems efficiently making use of tree decompositions.
In the second part of the module we introduce monadic second order logic (MSO) on graphs and we prove a famous theorem by Bruno Courcelle that shows how to solve **all** problems expressible in MSO efficiently on "tree-like" graphs. This includes all aforementioned algorithmic problems.
We make links to state-of-the-art research in the area and to practical applications, e.g. in compiler construction.

Learning outcomes:

On completion of this module, students should
- be familiar with classical NP-complete problems on graphs and how to solve them efficiently on trees using dynamic programming
- be able to demonstrate an in-depth understanding of tree decompositions, algorithms for computing tree decompositions, and algorithms on tree decompositions
- be able to demonstrate an in-depth understanding of the cops-and-robber game, its game theoretic properties and its connection to tree decompositions
- be able to design algorithms for the relevant problems, including analysis of runtime and correctness proofs
- be able to explain the main results covered by the module, in particular Courcelle's Theorem, demonstrating an understanding by discussing examples and knowing the main proof ideas
- be aware of the practical applications and limitations of the results
- appreciate and understand in-depth the role of proofs in the area of algorithm design

- recognise how the methods learned can be extended and used to solve other problems.

Remark:
The workload for this module is approxmately structured as follows:

- Participation in lectures and tutorials: 45 hrs
- Preparing and revising the lectures and tutorials: 60 hours
- Solving the worksheets: 45 hrs
- Exam preparation: 30 hrs

prerequisites for the module:
none

Recommended prior knowledge: Prerequisites: Algorithms and data structures, basic knowledge of predicate logic, proof techniques, interest in combinatorial games on graphs. Good English language skills.		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:** from 3.	**Minimal Duration of the Module:** 1 Semester

Module Units	
Tree Decompositions, Algorithms and Games **Mode of Delivery:** Lectures and Practicals **Language:** English/German **Frequency:** every winter semester	**4,00 Weekly Contact Hours**

Contents:
The lectures introduce the topics, providing an in-depth explanation including motivation, intuition, examples and proofs, as well as tools, techniques and applications.

The tutorials consist of hands-on problem solving, including exam-style problems.

Literature:

- Reinhard Diestel: Graph Theory, Springer 2017
- Jörg Flum, Martin Grohe: Parameterized Complexity Theory, Springer 2010
- Anthony Bonato, Richard J. Nowakowski: The Game of Cops and Robbers on Graphs, American Mathematical Society, 2011
- Bruno Courcelle, Joost Engelfriet: Graph Structure and Monadic Second-Order Logic: A Language-Theoretic Approach (Encyclopedia of Mathematics and its Applications Book 138), Cambridge University Press, 2012

Examination
No type selected / Duration of Examination: 90 minutes
Description:
Oral exam (30 minutes) or written exam (90 minutes).

Depending on the number of participants, the exam will either be an oral exam or a written exam. The mode of examination will be communicated in the first lecture.

Module CG-ProjCGA-B Project Computer Graphics *Bachelorprojekt Computergrafik*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Sophie Jörg		
Contents: Autodesk Maya is a software that is widely used in the creation of 3D movies. In this course, you will learn how to create and animate your own 3D animations using Maya. Topics for the course include 3D graphics concepts, modeling, shading, texturing, lighting, rendering, animation, and rigging. Participants will gain first experience in smaller individual projects and be able to expand their knowledge in a larger group project.		
Learning outcomes: The workload of this module is expected to be roughly as follows: • Class meetings: ~ 35h • Weekly assignments: ~ 35h • Individual projects: ~ 40h • Group project: ~60h • Written report and presentation: ~10h		
prerequisites for the module: none		
Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Bachelorprojekt Computergrafik **Mode of Delivery:** **Language:** German/English **Frequency:** winter or summer semester, on demand **Learning outcome:** The workload of this module is expected to be roughly as follows: • Class meetings: ~ 35h • Weekly assignments: ~ 35h • Individual projects: ~ 40h • Group project: ~60h • Written report and presentation: ~10h **Contents:** Autodesk Maya is a software that is widely used in the creation of 3D movies. In this course, you will learn how to create and animate your own 3D animations using Maya. Topics for the course include 3D graphics concepts, modeling, shading, texturing, lighting, rendering, animation, and rigging. Participants will gain first experience in smaller individual projects and be able to expand their knowledge in a larger group project.	**4,00 Weekly Contact Hours**

Examination Coursework Assignment and Colloquium	

Module CG-ProjCGA-M Project Computer Graphics *Masterprojekt Computergrafik*		6 ECTS / 180 h
(since SS23) Person responsible for module: N.N.		
Contents: Autodesk Maya is a software that is widely used in the creation of 3D movies. In this course, you will learn how to create and animate your own 3D animations using Maya. Topics for the course include 3D graphics concepts, modeling, shading, texturing, lighting, rendering, animation, and rigging. Participants will gain first experience in smaller individual projects and be able to expand their knowledge in a larger group project.		
Learning outcomes: The workload of this module is expected to be roughly as follows: • Class meetings: ~ 35h • Weekly assignments: ~ 35h • Individual projects: ~ 40h • Group project: ~60h • Written report and presentation: ~10h		
prerequisites for the module: verpflichtende Nachweise de		
Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Masterprojekt Computergrafik **Mode of Delivery:** **Language:** German/English	**4,00 Weekly Contact Hours**

Examination Coursework Assignment and Colloquium	

<table>
<tr><td colspan="2">Module CG-ProjVRAR-B Project Virtual Reality / Augmented Reality
Project Virtual Reality / Augmented Reality</td><td>6 ECTS / 180 h</td></tr>
<tr><td colspan="3">(since WS23/24)
Person responsible for module: Prof. Dr. Sophie Jörg</td></tr>
<tr><td colspan="3">Contents:
Virtual reality and augmented reality are becoming increasingly popular. After learning basic concepts and tools, students will implement a VR/AR application typically in relation to current research projects.</td></tr>
<tr><td colspan="3">Learning outcomes:
Students learn how to design, implement, and program a VR/AR system in pracice. Teamwork, project management, and problem solving skills are trained.</td></tr>
<tr><td colspan="3">Remark:
The main programming language for implementation is C#.

The workload of this project is expected to be roughly as follows:
• Class meetings: ~35h
• Individual assignments and preparation: 40h
• Group project: ~90h
• Written report and presentation: ~15h</td></tr>
<tr><td colspan="3">prerequisites for the module:
none</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
Good programming skills in C# (or C++ or Java)

Previous knowledge in VR or AR through a course or seminar is advantageous.</td><td>Admission requirements:
none</td></tr>
<tr><td>Frequency: every winter semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
1 Semester</td></tr>
</table>

<table>
<tr><td colspan="2">Module Units</td></tr>
<tr><td>Project Virtual Reality / Augmented Reality
Mode of Delivery:
Language: English/German
Frequency: every winter semester</td><td>4,00 Weekly Contact Hours</td></tr>
<tr><td>Examination
Coursework Assignment and Colloquium / Duration of Examination: 30 minutes
prerequisites for module examination:
Regelmäßige Teilnahme an der Lehrveranstaltung</td><td></td></tr>
</table>

Module CG-ProjVRAR-M Project Virtual Reality / Augmented Reality *Project Virtual Reality / Augmented Reality*		6 ECTS / 180 h
(since WS23/24) Person responsible for module: Prof. Dr. Sophie Jörg		
Contents: Virtual reality and augmented reality are becoming increasingly popular. After learning basic concepts and tools, students will implement a VR/AR application typically in relation to current research projects.		
Learning outcomes: Students learn how to design, implement, and program a VR/AR system in pracice. Teamwork, project management, and problem solving skills are trained.		
Remark: The main programming language for implementation is C#. The workload of this project is expected to be roughly as follows: • Class meetings: ~35h • Individual assignments and preparation: 40h • Group project: ~90h • Written report and presentation: ~15h		
prerequisites for the module: none		
Recommended prior knowledge: Good programming skills in C# (or C++ or Java) Previous knowledge in VR or AR through a course or seminar is advantageous.		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Project Virtual Reality / Augmented Reality **Mode of Delivery:** **Language:** English/German **Frequency:** every winter semester	**4,00 Weekly Contact Hours**
Examination Coursework Assignment and Colloquium / Duration of Examination: 30 minutes **prerequisites for module examination:** Regelmäßige Teilnahme an der Lehrveranstaltung	

Module CG-SemCGA-B Seminar Computer Graphics and Animation *Seminar Computergrafik und Animation*		3 ECTS / 90 h
(since WS24/25) Person responsible for module: Prof. Dr. Sophie Jörg		
Contents: Computer generated content is very common, for example, in movies, virtual worlds or educational applications. In this seminar we will be learning about the foundations and current approaches of computer graphics research. Your task will include reading and discussing foundational and contemporary papers in the field. You will then create a presentation and a report focused on a particular aspect of the field.		
Learning outcomes: Participants will practice methods for reading, discussing, and presenting scintific literature about computer graphics systems, algorithms and technologies as well as methods for writing an academic report.		
prerequisites for the module: none		
Recommended prior knowledge: Modul CG-CGA-B Computergrafik und Animation		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Seminar Grundlagen der Computergrafik und Animation **Mode of Delivery:** Seminar **Language:** English/German **Frequency:** every summer semester	**2,00 Weekly Contact Hours**

Examination Internship report / Duration of Examination: 20 minutes Duration of Coursework: 2 months	

Module CG-SemVRAR-B Seminar Virtual Reality / Augmented Reality *Seminar Virtual Reality / Augmented Reality*		3 ECTS / 90 h
(since WS23/24) Person responsible for module: Prof. Dr. Sophie Jörg		
Contents: Virtual reality (VR) and augmented reality (AR) are becoming increasingly popular. In such worlds we are represented by virtual characters called avatars. In this seminar, we will explore topics related to virtual reality, augmented reality, and avatars. We will read and critically discuss state-of-the-art research, learn about experiment design in the field, identify open questions, and think about how to design experiments to answer these. Participants will choose selected subtopics and present them as well as create a written seminar report.		
Learning outcomes: Participants will practice methods for academic writing and presentations as well as get an understanding of current research topics in virtual reality and augmented reality.		
Remark: Typical work load: • Meetings and talks: ~20h • Literature search and reading: ~25h • Preparation of presentation: ~15h • Written report: ~30h		
prerequisites for the module: none		
Recommended prior knowledge: Basic knowledge in virtual reality or user studies is advantageous.		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Seminar Virtual Reality / Augmented Reality **Mode of Delivery:** Seminar **Language:** English/German **Frequency:** every winter semester	**2,00 Weekly Contact Hours**

Examination Internship report / Duration of Examination: 20 minutes Duration of Coursework: 2 months **Description:** Participants will give a talk on a selected topic and submit a written seminar report.	

Module CG-VRAR-M Virtual Reality / Augmented Reality *Virtual Reality / Augmented Reality*		6 ECTS / 180 h
(since SS24) Person responsible for module: Prof. Dr. Sophie Jörg		

Contents:

Virtual Reality (VR) and Augmented Reality (AR) are gaining in popularity. Virtual Reality allows users to explore interactive worlds by being immersed in a fully computer-generated environment. Augmented Reality (AR) enhances the real world by overlaying digital content onto the physical world. Applications include education, training, simulation, architecture, design, tourism, manufacturing, healthcare, navigation, entertainment, and social interactions.
This course introduces students to the funcamental principles of Virtual Reality and Augmented Reality. The core topics are

- Basic Principles and Visual Perception
- Display Technologies from Head-Mounted Displays for VR to handheld AR devices
- Tracking Technologies
- Navigation and Interaction
- Avatars and Self-Avatars
- Evaluating AR and VR Experiences and Systems

Learning outcomes:

At the end of this course, students have a comprehensive understanding of the principles associated with VR and AR technologies. They understand how different display and tracking technologies work. Students can determine the basic requirements on hardware, interaction, and interface configurations for specific applications. They are able to design, implement, and evaluate a VR and AR system for a specified application.

prerequisites for the module:

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Recommended prior knowledge: Programming skills in C# (or C++ or Java).		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units

1. Virtual Reality / Augmented Reality **Mode of Delivery:** Lectures **Language:** English/German **Frequency:** every summer semester **Contents:** See module description. **Literature:** Literature will be specified at the beginning of the course.	**2,00 Weekly Contact Hours**
2. Virtual Reality / Augmented Reality **Mode of Delivery:** Practicals	**2,00 Weekly Contact Hours**

Language: English/German **Frequency:** every summer semester	
Contents: The labs will apply and expand the knowledge gained in the lectures with experience in the practical implementation of VR and AR systems. To this aim, students are required to complete assignments and projects.	

Examination Written examination **Description:** Die Prüfungsdauer wird in der ersten LV bekannt gegeben.	

Module DS-ConvAI-M Advanced Dialogue Systems and Conversational AI *Advanced Dialogue Systems and Conversational AI*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Stefan Ultes		
Contents: This module deals with state-of-the-art approaches to Conversational AI - text-based or speech-based dialogue interaction through language - and its modelling and realisation through machine learning and deep learning. Building upon content of the module DS-IDS-M, it dives into the technical realization of chatbots and spoken dialogue systems ranging from a modular pipeline architecture to end-to-end neural models including Large Language Models (LLMs). The module can be successfully completed without prior knowledge on dialogue systems.		
Learning outcomes: In this course, students will learn/recap theoretical foundations about conversational AI and dialogue systems technology and modelling. Participants will learn about various technological aspects of conversational AI with a focus on state-of-the-art neural, and deep learning approaches to sequential and non-sequential supervised learning also touching the usage of linguistic representations such as word embeddings. Students will gain insights into dialogue modelling through reinforcement learning and deep reinforcement learning and how to derive a suitable objective function. Participants will learn how to make use of advanced deep learning architectures like recurrent neural networks and transformers for their application on various problems of dialogue systems and the dialogue system itself. The lecture is accompanied by practicals and assignments that will help participants to develop practical, hands-on experience. In those practicals, students will implement and evaluate different approaches for dialogue systems and its modules using machine learning algorithms using Python and its respective commonly used libraries.		
Remark: The lecture is conducted in English. The workload of this module is expected to be roughly as follows: • Lecture: 21h • Preparation of lectures and analysis of further sources: 30h • Practicals accompanying lecture: 21h • Work on the actual assignments: 75h • Preparation for exam: 30h		
prerequisites for the module: none		
Recommended prior knowledge: Good working knowledge of programming (e.g., in Python); Recommended (not mandatory) completion of modules: Einführung in die KI/Introduction to AI [AI-KI-B], Einführung in die Dialogsysteme/ Introduction to Dialogue Systems [DS-IDS-B], Deep Learning [xAI-DL-M]		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** Semester

Module Units	
1. Advanced Dialogue Systems and Conversational AI **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Stefan Ultes **Language:** English/German **Frequency:** every summer semester **Learning outcome:** see module description **Contents:** The lecture will be held in English. The following is a selection of topics that will be addressed in the course: • Machine-larning based methods to various spoken dialogue system modules • Statistical Spoken Dialogue Systems • Large Language Models and their application in Conversational AI • End-to-end Neural Dialogue Generators • Evaluation techniques	**2,00 Weekly Contact Hours**
2. Advanced Dialogue Systems and Conversational AI (Practicals) **Mode of Delivery:** Practicals **Lecturers:** N.N. **Language:** English/German **Frequency:** every summer semester **Learning outcome:** see module description **Contents:** Further exploration of concepts discussed in the lecture, often accompanied by assigments and programming exercises implemented in Python and the corresponding machine/deep learning libraries.	**2,00 Weekly Contact Hours**

Examination Oral examination / Duration of Examination: 30 minutes **Description:** The content that is relevant for the exam consists of the content presented both in the lecture and in the practicals (including the assignments).	

Module DS-Proj-M Project Dialogue systems *Project Dialogue Systems*	6 ECTS / 180 h

(since WS24/25)
Person responsible for module: Prof. Dr. Stefan Ultes

Contents:
The goal is to implement and gain a practical understanding of the different modules of a spoken dialogue system. The focus will lay on the basic functionality of each module and how to implement it in an industry-like development process. Participants will gain theoretical knowledge about the dialogue system modules with a stronger focus on practical knowledge by implementing these modules using a ticket-based development flow. At the end of the semester, each group will present their results together with a demo of the system and each student will hand in a technical project report.

Learning outcomes:
The learning goals for this course are the following: the participants

- learn to familiarise themselves individually with the practical aspects of dialogue systems and to share these with their group members,
- are able to implement parts of a dialogue system to realize a given use-case scenario,
- understand, how the dialogue system modules operate and inter-operate with each other
- are able to realize a challenging implementation task as a team using industry-like development flows, identify challenges that arise from such a way working and jointly find solutions.

Remark:
The project provides the opportunity to work in groups of 4-5 students in a hands-on fashion. For the implementation and project work, you are expected use Python and git. Other libraries are free to choose.

Typical work load:

- Meetings and talks: ~25h
- Familiarization with the project: ~30h
- Implementation: ~90h
- Preparation of presentation and report: ~35h

prerequisites for the module:
none

Recommended prior knowledge: Good working knowledge of programming (e.g., in Python) and git; Recommended completion of modules: Einführung in die KI/ Introduction to AI [AI-KI-B], Einführung in die Dialogsysteme/ Introduction to Dialogue Systems [DS-IDS-B]		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** Semester

Module Units

Project Dialogue Systems **Mode of Delivery:** **Lecturers:** Prof. Dr. Stefan Ultes **Language:** English/German **Frequency:** every semester	**4,00 Weekly Contact Hours**

Learning outcome: see module description	
Contents: The students will need to find their own implementation for the dialogue system modules for a given use-case scenario: • Natural Language Understanding • Dialogue Management • Natrual Language Generation	

Examination Coursework Assignment and Colloquium / Duration of Examination: 45 minutes **Description:** The content of the colloquium and the term paper consists of the implementation work done during the course of the semester. The terms and conditions (e.g., deadline) of the term paper and of the colloquium will be announced at the beginning of each course.	

Module DS-Sem-M Master Seminar Conversational AI *Master Seminar Conversational AI*		3 ECTS / 90 h
(since SS23) Person responsible for module: Prof. Dr. Stefan Ultes		
Contents: Chatbots like ChatGPT and digital personal assistants like Siri, Google Assistant and Alexa have become indispensable in today's world thanks to their ability to engage in language-based interaction. These systems are classified as conversational AI or (spoken) dialogue systems. In this module, participants will dive deep into the Conversational AI literature and scientifically prepare and present a state-of-the-art research topic.		
Learning outcomes: The learning goals for this course are the following: the participants • learn to familiarise themselves individually and independently with their respective topic, • train and understand methods of scientific writing and oral communication, • learn to discuss and evaluate methods and approaches in the area of Conversational AI, • develop a deep understanding of their respective topic including possible applications and limitations.		
Remark: The seminar provides the opportunity to work alone or in small groups up to 3 students, depending on the topic and the total number of students in the seminar. Typical work load: • Meetings and talks: ~10h • Familiarization with and research about the topic: ~40h • Preparation of the presentation: ~15h • Preparation of the term paper: ~25h		
prerequisites for the module: none		
Recommended prior knowledge: Good knowledge of Machine Learning and Deep Learning recommended; Recommended completion of modules: xAI-DL-M: Deep Learning		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Master Seminar Conversational AI **Mode of Delivery:** Seminar **Language:** English/German **Frequency:** every semester **Learning outcome:** see module description **Contents:** The Seminar covers topics from Conversational AI, with each semester having a different theme and execution.	**2,00 Weekly Contact Hours**

Examination Coursework Assignment with presentation / Duration of Examination: 45 minutes **prerequisites for module examination:** Regular and active participation in the seminar **Description:** The content of the colloquium and the term paper consists of the implementation work done during the course of the semester. The terms and conditions (e.g., deadline) of the term paper and of the presentation will be announced at the beginning of each course.	

Module DSG-IDistrSys-B Introduction to Distributed Systems *Introduction to Distributed Systems*	6 ECTS / 180 h 45 h Präsenzzeit 135 h Selbststudium
(since WS24/25) Person responsible for module: Prof. Dr. Guido Wirtz	

Contents:

Nowadays infrastructure and business relies more or less on distributed systems of various flavors. Most of our civilization would not work any more if all distributed systems would fail. So, that should be a good reason for anyone planning to work in the context of IT to learn at least about the characteristics and basic issues of such systems. The course introduces to the different flavors of and issues with distributed systems, discusses the most basic problems arising with this kind of systems and presents solutions and techniques that are essential to make distributed systems work. Additionally, the course also teaches how to build simple distributed systems using Java-based technologies like process interaction, synchronization, remote message invocation and web service infrastructure. Students are required to work (in groups) on assignments in order to combine the theoretical concepts with practical experience and ... Yes, we program!

Learning outcomes:

Students know about the characteristics and different flavors of distributed systems and understand the essential differences compared to monolithic, centralized systems as well as their consequences when designing and building distributed systems. Students are able to apply the basic algorithmic techniques and programming paradigms in order to build simple distributed systems themselves. Students have gained basic experience with practically building and running distributed systems.

Remark:

The language of instruction in this course is English.

The overall workload of 180h for this module consists of:

- weekly classes: 22.5h
- tutorials: 22.5h
- Work on assignment: 75h
- Literature study 30h
- preparation for and time of the final exam: 30h

This course is intended for 2nd/3rd year bachelor students as well as master students which have not enrolled in a similar course during their bachelor studies. In case of questions don't hesitate to contact the person responsible for this module.

prerequisites for the module:

none

Recommended prior knowledge:	**Admission requirements:**
Knowledge of the basics of computer science in general, esp. operating systems, as well as practical experience in Java programming, as the subjects taught in DSG-EiAPS-B and DSG-EiRBS-B. Preferable also knowledge about multithreading and synchronization like, e.g., the subject-matters of DSG-PKS-B. Module Introduction to Parallel and Distributed Programming (DSG-PKS-B) - recommended	none

Frequency: every summer semester	Recommended semester: from 4.	Minimal Duration of the Module: 1 Semester

Module Units	
1. Lectures Introduction to Distributed Systems **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Guido Wirtz **Language:** English/German **Frequency:** every summer semester **Learning outcome:** c.f. overall module description **Contents:** c.f. overall module description **Literature:** • George Coulouris, Jean Dollimore, Tim Kindberg, Gordon Blair: Distributed Systems. Pearson Education UK, 2011 (5. Auflage); ISBN: 9780273760597 • Kenneth P. Birman: Guide to Reliable Distributed Systems. Springer Texts in CS, Springer Verlag, 2012, ISBN 978-1-4471-2415-3	**2,00 Weekly Contact Hours**
2. Tutorials Introduction to Distributed Systems **Mode of Delivery:** Practicals **Lecturers:** Scientific Staff Praktische Informatik **Language:** English/German **Frequency:** every summer semester **Learning outcome:** c.f. overall module description **Contents:** Introduction to and discussion of tools and practical issues closely related to the topics discussed in the lecture as well as solutions of problems that come up during working on the practical assignment. **Literature:** c.f. overall module description	**2,00 Weekly Contact Hours**

Examination Coursework Assignment and Colloquium / Duration of Examination: 10 minutes Duration of Coursework: 3 months **Description:** Oral examination concerning the topics discussed in the lecture, exercises and assignment. **Students may choose English or German as the language for the oral examination.** Examinations will take place at the end of the summer term or at the begin of the winter term (students may choose one of them). Students are assumed to work on a programming assignment ('schriftliche Hausarbeit') during the semester that is introduced at the beginning of the	

semester and uses the most important technologies discussed during the semester. **Note:** Without working on the programming assignment over the term students may run into problems during their oral examination (Kolloquium) as we discuss questions concerning topics from the lectures as well as from the assignment; questions about the assignment are based on the assignment solution programmed by the students.	

Module DT-CPP-B Introduction into Systems Programming in C++ *Einführung in die Systemprogrammierung in C++*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Maximilian Schüle		
Contents: Vertiefung der Kenntnisse über moderne C++-Programmiertechniken und das C++-Ökosystem, Erlernen des Schreibens von gutem C++, Erlernen der Implementierung großer Systeme mit C++, Erlernen des Schreibens von Hochleistungscode mit C++. Wir erwarten nicht, dass Sie bereits Erfahrung in der Programmierung mit C oder C++ haben, aber Sie sollten mit einer allgemeinen Programmiersprache Ihrer Wahl vertraut sein. Außerdem sollten Sie mit gängigen Algorithmen und Datenstrukturen sowie mit Computerarchitektur und Betriebssystemen vertraut sein.		
Learning outcomes: Systemprogrammierung in C++		
prerequisites for the module: none		
Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:** from 3.	**Minimal Duration of the Module:** 1 Semester

Module Units	
Einführung in die Systemprogrammierung in C++ **Mode of Delivery:** Lectures and Practicals **Lecturers:** Prof. Dr. Maximilian Schüle **Language:** English **Frequency:** every winter semester **Contents:** Vertiefung der Kenntnisse über moderne C++-Programmiertechniken und das C++-Ökosystem, Erlernen des Schreibens von gutem C++, Erlernen der Implementierung großer Systeme mit C++, Erlernen des Schreibens von Hochleistungscode mit C++. Wir erwarten nicht, dass Sie bereits Erfahrung in der Programmierung mit C oder C++ haben, aber Sie sollten mit einer allgemeinen Programmiersprache Ihrer Wahl vertraut sein. Außerdem sollten Sie mit gängigen Algorithmen und Datenstrukturen sowie mit Computerarchitektur und Betriebssystemen vertraut sein.	**4,00 Weekly Contact Hours**
Examination Portfolio / Duration of Examination: 30 minutes Duration of Coursework: 4 months	

Module DT-CPP-M Advanced Systems Programming in C++ (Master) *Fortgeschrittene Systemprogrammierung in C++ (Master)*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Maximilian Schüle		
Contents: In diesem Modul wird die fortgeschrittene Systemprogrammierung in C++ gelehrt. Dabei lernen die Teilnehmer nicht nur ihr Wissen in kleinen Programmierhausaufgaben anzuwenden sondern auch das gelernte Wissen in einer übergreifenden Projektarbeit zu kombinieren.		
Learning outcomes: Anwendung komplexer C++-Systemprogrammierung in eigenständiger Projektarbeit		
prerequisites for the module: none		
Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:** from 3.	**Minimal Duration of the Module:** 1 Semester

Module Units	
Fortgeschrittene Systemprogrammierung in C++ (Master) **Mode of Delivery:** Lectures and Practicals **Lecturers:** Prof. Dr. Maximilian Schüle **Language:** English **Frequency:** every winter semester **Learning outcome:** Anwendung komplexer C++-Systemprogrammierung in eigenständiger Projektarbeit **Contents:** In diesem Modul wird die fortgeschrittene Systemprogrammierung in C ++ gelehrt. Dabei lernen die Teilnehmer nicht nur ihr Wissen in kleinen Programmierhausaufgaben anzuwenden sondern auch das gelernte Wissen in einer übergreifenden Projektarbeit zu kombinieren. **Literature:** Primary • C++ Reference Documentation • Lippman, 2013. C++ Primer (5th edition). • Stroustrup, 2013. The C++ Programming Language (4th edition). • Meyers, 2015. Effective Modern C++. 42 Specific Ways to Improve Your Use of C++11 and C++14. Supplementary • Aho, Lam, Sethi & Ullman, 2007. Compilers. Principles, Techniques & Tools (2nd edition).	**4,00 Weekly Contact Hours**

• Tanenbaum, 2006. Structured Computer Organization (5th edition).	
Examination Portfolio / Duration of Examination: 30 minutes Duration of Coursework: 4 months	

Module DT-DB4MLKD-B Modern Database Systems for Machine Learning and Knowledge Discovery *Moderne Datenbanksysteme für maschinelles Lernen und Wissensentdeckung*		3 ECTS / 90 h
(since WS24/25) Person responsible for module: Prof. Dr. Maximilian Schüle		
Contents: In this seminar, we study the challenges of modern database systems. We discuss the topic along with very recent publications about database systems for machine learning and knowledge discovery.		
Learning outcomes: selbständig Publikationen schreiben		
prerequisites for the module: none		
Recommended prior knowledge: none		**Admission requirements:** none
Frequency: winter and summer semester, on demand	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Moderne Datenbanksysteme für maschinelles Lernen und Wissensentdeckung **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Maximilian Schüle **Language:** English **Frequency:** winter and summer semester, on demand **Learning outcome:** selbständig Publikationen schreiben **Contents:** In this seminar, we study the challenges of modern database systems. We discuss the topic along with very recent publications about database systems for machine learning and knowledge discovery.	**3,00 Weekly Contact Hours**

Examination Internship report / Duration of Examination: 30 minutes Duration of Coursework: 14 days	

Module DT-DBCPU-M Database Systems for modern CPU *Datenbanksysteme für moderne CPU*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Maximilian Schüle		
Contents: This lecture covers the implementation of database systems, including how to leverage modern hardware architectures, for example vector intrinsics (AVX-512) and CUDA programming for GPU. Diese Vorlesung behandelt die Implementierung von Datenbanksystemen, einschließlich der Nutzung moderner Hardware-Architekturen, z.B. Vektorinstruktionen (AVX-512) und CUDA-Programmierung für die GPU.		
Learning outcomes: Konzepte von Datenbanksystemen verstehen und Datenbanksysteme implementieren können inkl. für moderne Hardware		
prerequisites for the module: none		
Recommended prior knowledge: MOBI-DBS-B		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Datenbanksysteme für moderne CPU **Mode of Delivery:** Lectures and Practicals **Lecturers:** Prof. Dr. Maximilian Schüle **Language:** English **Frequency:** every summer semester **Learning outcome:** Konzepte von Datenbanksystemen verstehen und Datenbanksysteme implementieren können inkl. für moderne Hardware **Contents:** This lecture covers the implementation of database systems, including how to leverage modern hardware architectures, for example vector intrinsics (AVX-512) and CUDA programming for GPU. Diese Vorlesung behandelt die Implementierung von Datenbanksystemen, einschließlich der Nutzung moderner Hardware-Architekturen, z.B. Vektorinstruktionen (AVX-512) und CUDA-Programmierung für die GPU. **Literature:** • Theo Härder, Erhard Rahm.Datenbanksysteme: Konzepte und Techniken der Implementierung.Springer, Berlin; 2nd ed. • Hector Garcia-Molina, Jeff Ullman, Jennifer Widom. *Database Systems: The Complete Book* • D. E. Knuth.The Art of Computer Programming Volume III	**4,00 Weekly Contact Hours**

• Joseph M. Hellerstein, Michael Stonebraker, James Hamilton.Architecture of a Database System • Franz Faerber, Alfons Kemper, Per-Åke Larson, Justin J. Levandoski, Thomas Neumann, Andrew Pavlo.Main Memory Database Systems	

Examination Written examination / Duration of Examination: 20 minutes	

Module DT-Proj-B Bachelor Project: Data Engineering *Bachelor-Projekt: Data Engineering*		6 ECTS / 180 h
(since SS24) Person responsible for module: Prof. Dr. Maximilian Schüle		
Contents: Projekte zu Data Engineering		
Learning outcomes: vertiefendes wissenschaftliches Arbeiten im Rahmen eines Data Engineering Projektes		
prerequisites for the module: none		
Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Bachelor-Projekt: Data Engineering **Mode of Delivery:** **Lecturers:** Prof. Dr. Maximilian Schüle **Language:** English **Frequency:** every semester **Contents:** Bachelor-Projekte zu Data Engineering	**4,00 Weekly Contact Hours**
Examination Colloquium, Coursework Assignment / Duration of Examination: 30 minutes Duration of Coursework: 3 months	

Module DT-Proj-M Project: Data Engineering *Projekt: Data Engineering*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Maximilian Schüle		
Contents: Data Engineering projects		
Learning outcomes: In-depth scientific work as part of a data engineering project		
prerequisites for the module: none		
Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Projekt: Data Engineering **Mode of Delivery:** **Lecturers:** Prof. Dr. Maximilian Schüle **Language:** English **Frequency:** every semester **Contents:** Data Engineering projects	**4,00 Weekly Contact Hours**

Examination Colloquium, Coursework Assignment / Duration of Examination: 30 minutes Duration of Coursework: 3 months	

Module EESYS-ADAML-M Applied Data Analytics and Machine Learning in R *Applied Data Analytics and Machine Learning in R*	6 ECTS / 180 h
(since SS21) Person responsible for module: Prof. Dr. Thorsten Staake	

Contents:

This course provides the theoretical foundation and conveys hands-on skills in the fields of data analytics and machine learning using the statistics software GNU R. It uses real-word datasets from the realm of energy efficiency and consumer behavior and conveys the subject matter through real-world examples and practical challenges.

Following a refresher in descriptive statistic, the course covers

- an introduction to the statistics software GNU R,
- the design of field experiments and the use of Information Systems to collect behavioral data,
- techniques to formulate, solve, and interpret linear and logistic regression analyses,
- techniques to formulate, solve, and interpret clustering analyses,
- setting up, training, and evaluating machine learning algorithms, including KNN, regression, and support vector machines, and
- ethical issues and data privacy regulations.

Learning outcomes:

After a successful participation in this course, participants can

- translate new business and research questions that can be answered using empirical methods into suitable experimental designs,
- plan and conduct corresponding experiments,
- choose suitable methods from the set of methods presented in class to analyze the data,
- explain their design choices, the choice of methods, and the steps of the analyses,
- apply the methods correctly and efficiently using the statics software R,
- adjust the methods if needed to solve new and specific problems based on an understanding of the necessary theories,
- interpret the outcome of such analyses and identify the strengths and limitations of the approaches, and
- reflect upon data protection, privacy and ethical issues related to powerful techniques for data acquisition and analytics.

Remark:

The lecture will be held as a self-paced, video-based online lecture.

The tutorials take place once per week as in-classroom events.

The online lecture includes instructional videos (scripted, i.e., with subtitles), reading material, exemplary data sets, and a multitude of online and offline tasks. It also includes an online discussion forum.

The online lecture is supported by three classroom lectures (in addition to the classroom tutorials):

1. Classroom lecture: The introductory event includes a course overview and motivation. Moreover, credentials to access the online resources will be announced. Date: First week of the semester.

2. Classroom lecture: This intermediate session includes a review of the concepts covered so far. It should help participants to self-assess their learning progress. Date: Announced in the first week of the semester.
3. Classroom lecture: Exam preparation and Q&A. Date: Last week of the semester.

An introduction to the statistics software GNU R will be given as in-classroom event during the tutorials at the beginning of the semester.

prerequisites for the module:
none

Recommended prior knowledge: This course requires a basic understanding of statistics (e.g., from a bachelor-level course). A statistics repetition and is part of the online material of the course and the of the first tutorials and should be complemented in self-study if necessary. Basic familiarity with a programming language.		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units

1. Lectures Data Analytics in Energy Informatics **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Thorsten Staake **Language:** German/English **Frequency:** every winter semester	**2,00 Weekly Contact Hours**
Contents: The video-based online lecture is divided into two parts. Part 1 conveys the statistical basics required for the module, including, for example, properties of random distributions and descriptive and injunctive statistics. This part serves as refresher of bachelor-level statistics and thereby enables students with no statistics-knowledge beyond a basic introductory course to participate. Part 2 covers the methods outlined in “Module EESYS-DAE-M” subsection “Contents”. It includes both, the theory behind the concepts and their application using R. Both, Part 1 and Part 2 use datasets and examples from industry and research and provides many hands-on examples. In order to deepen the understanding and to ease the transfer of the methods to new problems and settings, mini-tasks and small exercises are part of the online lecture.	
Literature: Reading material will be announced in class.	
2. Practicals Data Analytics in Energy Informatics **Mode of Delivery:** Practicals **Language:** German/English **Frequency:** every winter semester	**2,00 Weekly Contact Hours**
Contents: In the classroom tutorial, participants apply the methods, tools, and theories conveyed in the lecture to exemplary problems and to new challenges. This includes solving smaller tasks (e.g., acing case studies, working on concrete	

data problems) on paper and using the statistics software GNU R. Tasks are addressed individually or in small teams. The tutorials can also cover new content, especially when its immediate application supports the learning process. Selected tutorials contain a self-assessment of the learning progress. An introduction to GNU R is given in the first sessions.	

Examination Written examination / Duration of Examination: 90 minutes **Description:** The examination covers subject matter taught in the lectures and tutorials. The examination can also cover transfers of the subject matter to new problems and settings. Students can achieve up to 90 points. Through the voluntary completion of coursework (“bonus exercises”) during the semester, participants can collect up to 12 additional points that are counted towards the exam, given that the exam is passed also without points from bonus exercises. Bonus exercises can take the form of written assignments, presentations, or smaller software projects. Points from bonus exercises are only valid in the semester they have been earned in and in the immediately following semester. In the first week of the course, the publishing dates of bonus exercise tasks, the submission deadlines, and the points per bonus exercise will be announced. It is possible to pass the exam with a grade of 1.0 also without points from bonus exercises. Exam questions are stated in English, answers can be given in German or English.	

<table>
<tr><td colspan="2">Module EESYS-BIA-M Business Intelligence & Analytics
Business Intelligence & Analytics</td><td>6 ECTS / 180 h</td></tr>
<tr><td colspan="3">(since WS21/22)
Person responsible for module: Dr. Konstantin Hopf</td></tr>
<tr><td colspan="3">Contents:
This module covers topics from the field of Business Intelligence, Data Science, and Business Analytics and introduces data-driven decision support. The main topics include

the role of Business Intelligence in organizations,
the data analytics process using the CRISP-DM process model,
data sources in organizations and publicly available data sources,
an introduction to Data Science and the basics of data analytics including a repetition of the fundamentals of descriptive statistics and data visualization,
fundamentals of spatio-temporal data analysis,
advanced analytics methods including unsupervised and supervised machine learning, optimization and simulation, and
legal and ethical aspects of data analytics (in particular privacy, data security and copyright).

Students approach the topics by means of concrete data analytics examples and case studies in the programming environment GNU R. The course covers the most important steps of the data analytics process (business understanding, data understanding, data preparation, modeling, evaluation and deployment).</td></tr>
<tr><td colspan="3">Learning outcomes:
Students will be able to

describe the role of business intelligence and data analyses in organizations,
identify available internal and publicly available data sources, make them usable and describe the data,
apply advanced analytics methods (especially: k nearest neighbor, Decision Trees, Support Vector Machines, Random Forest) in the software R on their own and create analyses for business-relevant questions, which can be used as a basis for decision-making,
visualize the results of the analyses in a meaningful way, and
describe selected ethical and legal aspects of data analytics.
</td></tr>
<tr><td colspan="3">prerequisites for the module:
none</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
This course requires a basic understanding of statistics (e.g., from a bachelor-level course). A statistics repetition is part of the course and should be complemented in self-study if necessary.
Basic familiarity with a programming language.</td><td>Admission requirements:
none</td></tr>
<tr><td>Frequency: every winter semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
1 Semester</td></tr>
</table>

Module Units	
1. Lectures Business Intelligence & Analytics **Mode of Delivery:** Lectures **Lecturers:** Dr. Konstantin Hopf **Language:** German/English **Frequency:** every winter semester **Contents:** The lecture covers the topics mentioned in “Module EESYS-BIA-M”, subsection “Contents”. Traditional lecture elements, case studies, discussions, exercises, and group work are used to support participants in reaching the learning objectives. Methods, tools, and theories are introduced with references to practical challenges and applied to exemplary problems. For selected topics, the lectures rely on flipped classroom elements for which participants need to acquire knowledge in advance (e.g., through reading tasks), which is then critically reflected and extended in the classroom lecture. The course materials are in English, the language of instruction is agreed upon in the first course together with the course participants. **Literature:** Reading material will be announced in class.	**2,00 Weekly Contact Hours**
2. Practicals Business Intelligence & Analytics **Mode of Delivery:** Practicals **Language:** German/English **Frequency:** every winter semester **Contents:** In the classroom tutorial, participants apply the methods, tools, and theories conveyed in the lecture to exemplary problems and to new challenges. This includes solving smaller tasks (e.g., acing case studies, working on concrete data problems) on paper and using the statistics software GNU R. Tasks are addressed in small teams or individually. The tutorials can also cover new content, especially when its immediate application supports the learning process. Selected tutorials contain a self-assessment of the learning progress. An introduction to GNU R is given in the first sessions.	**2,00 Weekly Contact Hours**
Examination Written examination / Duration of Examination: 90 minutes **Description:** The examination covers subject matter taught in the lectures and tutorials. The examination can also cover transfers of the subject matter to new problems and settings. Students can achieve up to 90 points. Through the voluntary completion of coursework (“bonus exercises”) during the semester, participants can collect up to 12 additional points that are counted towards the exam, given that the exam is passed also without points from bonus exercises. Bonus exercises can take the form of written assignments, presentations, or smaller software projects. Points from bonus exercises are	

only valid in the semester they have been earned in and in the immediately following semester. In the first week of the course, the publishing dates of bonus exercise tasks, the submission deadlines, and the points per bonus exercise will be announced. It is possible to pass the exam with a grade of 1.0 also without points from bonus exercises. Exam questions are stated in English, answers can be given in German or English.	

Module EESYS-DDS-M Data-driven Decision Support *Data-driven Decision Support*		6 ECTS / 180 h
(since WS21/22) Person responsible for module: Dr. Konstantin Hopf		
Contents: The module covers methods of modern decision theory and practice and teaches the most important concepts of data-driven decision support. The main topics covered include • the analysis of multi-criteria decision situations, • decision-making with scenarios (known or unknown probability of occurrence), • bias and heuristics in decision-making, • structuring of complex decisions, • the Analytic Hierarchy Process (AHP), • portfolio selection and optimization, • data-driven insights through Business Intelligence and advanced analytics, • expert systems and decision support systems, as well as • ethical and legal aspects of data-driven and automated decisions. The students will apply the learned contents practically on the basis of concrete tasks, partly using spreadsheet software or specialized software applications.		
Learning outcomes: Students will be able to • analyze and model complex decision situations considering several goals, alternatives, and decision-makers, • include uncertainties and probabilities in the analysis and modelling, • include the results of Business Intelligence and Advanced Analytics in decisions, • develop a simple expert system, and • describe selected ethical and legal aspects of data-driven decisions.		
prerequisites for the module: none		
Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Data-driven Decision Support **Mode of Delivery:** Lectures **Lecturers:** Dr. Konstantin Hopf **Language:** English/German **Frequency:** every summer semester **Contents:** The lecture covers the topics mentioned in “Module EESYS-DDS-M”, subsection “Contents”. Traditional lecture elements, case studies, discussions, exercises and group work are used to support participants in reaching the learning	**2,00 Weekly Contact Hours**

objectives. Methods, tools, and theories are introduced with references to practical challenges and applied to exemplary problems. For selected topics, the lectures rely on flipped classroom elements for which participants need to acquire knowledge in advance (e.g., through reading tasks), which is then critically reflected and extended in the classroom lecture. The course materials are written in English, the language of instruction is agreed in the first course together with the course participants. **Literature:** Reading material will be announced in class.	
2. Data-driven Decision Support **Mode of Delivery:** Practicals **Language:** English/German **Frequency:** every summer semester **Contents:** In the classroom tutorial, participants apply the methods, tools, and theories conveyed in the lecture to exemplary problems and to new challenges. This includes solving smaller tasks (e.g., acing case studies, working on concrete data problems) on paper and using software (e.g., Spreadsheets, SWI Prolog) that is available to students at the University of Bamberg. Tasks are addressed in small teams or individually. The tutorials can also cover new content, especially when its immediate application supports the learning process. Selected tutorials contain a self-assessment of the learning progress. An introduction to GNU R is given in the first sessions.	**2,00 Weekly Contact Hours**

Examination Written examination / Duration of Examination: 90 minutes **Description:** The examination covers subject matter taught in the lectures and tutorials. The examination can also cover transfers of the subject matter to new problems and settings. Students can achieve up to 90 points. Through the voluntary completion of coursework (“bonus exercises”) during the semester, participants can collect up to 12 additional points that are counted towards the exam, given that the exam is passed also without points from bonus exercises. Bonus exercises can take the form of written assignments, presentations, or smaller software projects. Points from bonus exercises are only valid in the semester they have been earned in and in the immediately following semester. In the first week of the course, the publishing dates of bonus exercise tasks, the submission deadlines, and the points per bonus exercise will be announced. It is possible to pass the exam with a grade of 1.0 also without points from bonus exercises. Exam questions are stated in English, answers can be given in German or English.	

Module EESYS-ES-M Energy Efficient Systems *Energieeffiziente Systeme*		6 ECTS / 180 h
(since WS19/20) Person responsible for module: Prof. Dr. Thorsten Staake		

Contents:

The course covers the design and application of Information Systems that help increase energy efficiency and reduce greenhouse gas emissions. It is directed to computer science and Information Systems students that want to apply their skills to challenges in the fields of energy, mobility, production, and sustainable consumption/consumer behavior.

The course introduces methods and theories from behavioral economics, operations management, and simulation analysis that help to understand, analyze, and shape both, industry processes and consumer behavior in the field of sustainability. Also covered are cost/benefit considerations on a micro- and macro-level (including, for example, rebound effects) and a discussion on the economic and societal implications of the subject matter.

The course includes an introduction to physics and energy engineering to allow students with very limited knowledge in these fields to participate successfully.

Learning outcomes:

Successful participants of this course shall acquire the skills to

- explain the physical and technical principals covered in this course and apply them to new problems,
- explain the components, influencing factors, requirements and challenges related to electric mobility and describe the contribution that Information Systems can make to solve the challenges; moreover, successful participants shall be able to set up data-based simulations to derive important characteristic variables related to electric vehicles, such as electric reachability, peak loads to electric grids, etc.,
- outline, assess, and conceptually model the potential of Information Systems and the effects to heating and room climate applications,
- explain in detail the characteristics of and implications from environmental business Information Systems,
- explain the discussed behavioral theories (e.g., the prospect theory), make use of them when building Information Systems that support decision making and behavioral change, and be able to evaluate the effectiveness of such systems, and
- evaluate the effects of the tools and methods introduced, including their micro- and macro-economic effects, and critically assess the techniques used to perform such evaluations.

Moreover, successful participants shall be able to apply the acquired skills to new challenges and adjust and extend them as needed.

Finally, the participants shall realize the scope for design and the potential that results from their IT studies to favorably shape a sustainable and socially desirable development of our society.

prerequisites for the module:

none

Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

<table>
<tr><td colspan="2">Module Units</td></tr>
<tr><td>1. Lectures Energy Efficient Systems
Mode of Delivery: Lectures
Lecturers: Prof. Dr. Thorsten Staake
Language: German/English
Frequency: every summer semester

Contents:
The lecture covers the topics mentioned in “Module EESYS-ES-M”, subsection “Contents”. It uses traditional lecture elements, discussions, exercises, and group work to support participants in reaching the learning objectives. Special emphasis is placed on working on cases and on discussions of studies and scientific publications. Methods, tools, and theories are introduced with references to practical challenges and are applied to exemplary problems.

For selected topics, the lecture relies on flipped classroom elements for which participants need to acquire knowledge in advance (e.g., through reading tasks), which is then critically reflected and extended in the classroom sessions.

Literature:
Weiterführende Unterlagen werden in der Veranstaltung bekanntgegeben.</td><td>2,00 Weekly Contact Hours</td></tr>
<tr><td>2. Practicals Energy Efficient Systems
Mode of Delivery: Practicals
Language: German/English
Frequency: every summer semester

Contents:
The first tutorials convey basics in physics and electrical engineering in order to also allow students who did not take related modules to participate in this course. Subsequently, participants apply the methods, tools, and theories conveyed in the lecture to exemplary problems and to new challenges. Tutorials include small tasks, case studies, and reviews of scientific publications that are addressed individually or in small teams.

The tutorials can also cover new content, especially when its immediate application supports the learning process. Selected tutorials contain a self-assessment of the learning progress.

Literature:
Reading material will be announced in class.</td><td>2,00 Weekly Contact Hours</td></tr>
</table>

<table>
<tr><td>Examination
Written examination / Duration of Examination: 90 minutes
Description:
The examination covers subject matter taught in the lectures and tutorials. The examination can also cover transfers of the subject matter to new problems and settings. Students can achieve up to 90 points.

Through the voluntary completion of coursework (“bonus exercises”) during the semester, participants can collect up to 12 additional points that are counted</td><td></td></tr>
</table>

towards the exam, given that the exam is passed also without points from bonus exercises. Bonus exercises can take the form of written assignments, presentations, or smaller software projects. Points from bonus exercises are only valid in the semester they have been earned in and in the immediately following semester. In the first week of the course, the publishing dates of bonus exercise tasks, the submission deadlines, and the points per bonus exercise will be announced. It is possible to pass the exam with a grade of 1.0 also without points from bonus exercises. Exam questions are stated in English, answers can be given in German or English.	

<table>
<tr><td colspan="2">Module EESYS-P-DINU-M Project Digital Nudges for Behavior Change in Enterprise Information Systems
Projekt Digital Nudges for Behavior Change in Enterprise Information Systems</td><td>6 ECTS / 180 h</td></tr>
<tr><td colspan="3">(since WS24/25)
Person responsible for module: Sebastian Günther</td></tr>
<tr><td colspan="3">Contents:
The value of information systems depends greatly on user behavior. This project focuses on the design and prototypical implementation of behavioral interventions in enterprise information systems, with the aim to increase important business metrics or achieve socially desirable effects. Students apply decision theories to develop innovative concepts, which they then actively embed into established information systems as software applications.

During the project, the following contents are covered in detail:

Fundamentals of behavioral economics and decision theory.
- In-depth examination of various theoretical models.
- Analysis of the applicability of these models in the context of a specific information system.

Creation of a nudging/intervention tool.
- Access to API methods for data extraction from the information system.
- Practical implementation of the behavioral interventions as a prototype.
- Integration of the prototype into the information system.
- Conducting simple system tests.

Sketching possible evaluation strategies for assessing user behavior.

The language of instruction is agreed upon in the first course together with the course participants.</td></tr>
<tr><td colspan="3">Learning outcomes:
After completing the module, students will have developed a current and practice-relevant IT tool to achieve desirable behavioral effects. Thereafter, students will be able to

- record, analyze, and develop concrete implementations of given requirements for a nudging tool, based on scientific literature,

- collect and process suitable data for the given problem,

- work in an agile project team,

prepare and hold project interim presentations that are appropriate to the target group and defend the approach and results.</td></tr>
<tr><td colspan="3">prerequisites for the module:
none</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
none</td><td>Admission requirements:
none</td></tr>
<tr><td>Frequency: every summer semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
Semester</td></tr>
</table>

Module Units	
Digital Nudges for Behavior Change in Enterprise Information Systems **Mode of Delivery:** **Lecturers:** Sebastian Günther **Language:** English/German **Frequency:** every summer semester	**4,00 Weekly Contact Hours**
Learning outcome: After completing the module, students will have developed a current and practice-relevant IT tool to achieve desirable behavioral effects. Thereafter, students will be able to - record, analyze, and develop concrete implementations of given requirements for a nudging tool, based on scientific literature, - collect and process suitable data for the given problem, - work in an agile project team, prepare and hold project interim presentations that are appropriate to the target group and defend the approach and results.	
Contents: The value of information systems depends greatly on user behavior. This project focuses on the design and prototypical implementation of behavioral interventions in enterprise information systems, with the aim to increase important business metrics or achieve socially desirable effects. Students apply decision theories to develop innovative concepts, which they then actively embed into established information systems as software applications. During the project, the following contents are covered in detail: Fundamentals of behavioral economics and decision theory. - In-depth examination of various theoretical models. - Analysis of the applicability of these models in the context of a specific information system. Creation of a nudging/intervention tool. - Access to API methods for data extraction from the information system. - Practical implementation of the behavioral interventions as a prototype. - Integration of the prototype into the information system. - Conducting simple system tests. Sketching possible evaluation strategies for assessing user behavior. The language of instruction is agreed upon in the first course together with the course participants.	
Literature: Reading material will be announced in class	
Examination Colloquium, Coursework Assignment / Duration of Examination: 20 minutes Duration of Coursework: 4 months	

prerequisites for module examination: Regelmäßige Teilnahme an der Lehrveranstaltung **Description:** Students work on a topic that will be announced in the first session. They create artifacts (e.g., source code, posters, documents), prepare a report and defend their results at the end of the semester in the form of a presentation. The artifact, the report, and the presentation are included in the evaluation. The work is carried out in groups, yet the contribution of each student is evaluated individually.	

Module GdI-CSNL-M Computational Semantics of Natural Language *Computational Semantics of Natural Language*	6 ECTS / 180 h
(since WS23/24) Person responsible for module: Prof. Ph.D. Michael Mendler further responsible : Luke Burke	

Contents:

The formal study of natural language syntax and semantics has developed as a very lively sub-field of linguistics in the past 50 years, with the typed lambda calculus in particular providing a way of giving compositional analyses of meanings in natural language. Recently, monads and continuations have been employed as tools in natural language syntax and semantics. The aim of this module is to introduce the use of monads and continuations in natural language semantics and to discuss different approaches to the formal representation of quantifier scope ambiguities in natural language. The basics of natural language semantics (typed lambda calculus) will be briefly introduced, before discussing a continuation-based approach to quantification in natural language, which will be contrasted with other approaches. Monads representing focus, intensionality and non-determinism in natural language will be discussed. We will look at how analyses of the meaning of sentences can be represented in Haskell.

Importantly, the course may differ slightly from other courses in that assessment will not concentrate on technical exercises; rather, we require careful reading and dissection of relevant literature on the topic, since the primary mode of assessment will be via seminar presentations and essays, and you will be assessed on your understanding of, and your independent analysis of, relevant literature discussed in lectures. Independent reading of this literature will in fact be essential.

This course may also be of interest to students in philosophy and linguistics.

Learning outcomes:

At the end of this course students should be familiar with different approaches to the formal representation of quantifier scope ambiguities in natural language; be familiar with how monads and continuations have been used in natural language semantics; be familiar with the use of Haskell to formalise analyses in natural language semantics; be able to produce and manipulate terms of the typed lambda calculus to represent how meanings combine; have an understanding of how both logics and trees have been used to represent natural language syntax; be acquainted with logics such as Montague's "Intensional Logic" and Gallin's Ty2.

Remark:

The workload for this module consists of:

- participation in lectures and tutorial sessions: 45hrs
- individual preparation and reading: 105hrs
- exam preparation and oral exam: 30hrs

prerequisites for the module:

none

Recommended prior knowledge: Willingness to read relevant literature, critically discuss and analyse it and write about it. Basic logic (Gdl-Mfl-1: Mathematik fur Informatik or an equivalent level of understanding). Some knowledge of modal logic more basic than that required for (Gdl-MTL: Modal and	**Admission requirements:** English language skills at Level B2 (UniCert II) or above.

Temporal Logic). Knowledge of the typed lambda calculus (abstraction and application) and elementary Haskell (GdI-IFP: Introduction to Functional Programming) would be very useful, though not essential.		
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** Semester

Module Units	
Computational Semantics of Natural Language **Language:** English **Frequency:** every summer semester **Contents:** Through prepared class presentations, essay writing, and direct interactions with the students the lecturer introduces the topics of the course in detail. The seminars deepen the students' understanding of the theoretical concepts and constructions covered in the lectures through presentations, which involve comparing alternative analyses of linguistic phenomena. **Literature:** • van Eijck, J. And Unger, Christina, “Computational Semantics with Functional Programming”, Cambridge University Press 2010 • Barker, C. and Shan, C.-C., “Continuations and natural language”, Volume 53. Oxford studies in Theoretical Linguistics, Oxford University Press, 2014 • Carpenter, Bob, “Type-Logical Semantics”, MIT Press (1997) • Keenan, Edward, and Stabler, Edward, “Mathematical structures in Language”, CSLI publications, Stanford, 2016 • Gallin, Daniel, “Intensional and Higher-Order Modal logic. North Holland, 1975.	**4,00 Weekly Contact Hours**

Examination Portfolio / Duration of Examination: 80 minutes **Description:** The components of the portfolio will be announced at the beginning of each semester.	

Module GdI-FPRS-M Functional Programming of Reactive Systems *Functional Programming of Reactive Systems*	6 ECTS / 180 h
(since WS23/24) Person responsible for module: Prof. Ph.D. Michael Mendler	

Contents:

Based on an existing basic knowledge of functional programming (FP), the aim of this module is to develop advanced skills in the use of FP languages to structure and solve algorithmic problems in designing interactive and concurrent systems. We will study advanced programming abstractions specifically developed for the functional modelling of synchronous reactive systems. Following the methodological structure of the introductory course GDI-IFP, this advanced course, too, combines both practical programming with a focused discussion of pertinent underlying mathematical concepts. Though we use Haskell as our main language we may also look at other FP languages such as F#, ML or OCAML where appropriate.

Learning outcomes:

At the end of this course students should

- be familiar with advanced FP programming concepts and their application (e.g., class mechanism, type families, higher-rank polymorphism, monad and arrow abstractions, lenses, continuation-style programming, stream programming, concurrency abstractions)
- be able to use these advanced language concepts to solve complex algorithmic problems efficiently, in particular involving the use of memory, concurrency and interaction
- be able use the Haskell stack build tool and understand the mechanisms of package management
- appreciate the importance of functional abstraction for conciseness and efficiency of programming complex applications
- be familiar with the second-order polymorphic lambda calculus (Hindley-Milner predicative let-polymorphism, impredicative System F) as an operational semantics behind (eager, lazy) functional programming
- be able to explain the encoding of recursive data structures in type theory
- have an elementary understanding of the execution model of functional languages and transformation to operational code through defunctionalisation and abstract machines.
- by able to use FP (specifically Haskell) as a development tool for the design of new programming languages

Remark:

The workload for this module splits up roughly like this:

- participation in lectures and tutorials: 45 hrs
- preparation of classes and tutorials as well literature research: 60 hrs
- solving (ungraded) programming exercises and participation in lab sessions: 45 hrs
- exam preparation: 30 hrs

prerequisites for the module:

none

Recommended prior knowledge:	**Admission requirements:**
Elementary programming skills in a functional programming language, such as from module GdI-IFP-B; Basic knowledge in the use of	none

temporal and modal logic specification formalisms such as from GdI-MTL-B. English language skills at Level B2 (UniCert II) or above. Module Introduction to Functional Programming (GdI-IFP-M) - recommended		
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Advanced Functional Programming **Mode of Delivery:** Lectures **Lecturers:** Prof. Ph.D. Michael Mendler **Language:** English/German **Frequency:** every summer semester **Contents:** Through class presentations and direct interactions with the students the lecturer introduces the topics of the course in detail, poses exercises and suggests literature for self-study. **Literature:** • S. Marlow: The Haskell 2010 Language Report. https://www.haskell.org/onlinereport/haskell2010/ • V. Zsók, Z. Horváth, R. Plasmeijer: Central European Functional Programming School. Springer 2012. • S. Marlow: Parallel and Concurrent Programming in Haskell: Techniques for Multicore and Multithreaded Programming, O'Reilly 2013. • B. O'Sullivan, J. Goerzen, D. Stewart: Real World Haskell. O'Reilly 2009. • Ch. Okasaki: Purely Functional Data Structures, CUP 1998 • F. Rabhi, G. Lapalme: Algorithms - A Functional Approach. • D. Syme, A. Granicz, A. Cisternino: Expert F#4.0, Apress 2015. • B. Pierce: Types and Programming Languages. MIT Press 2002. (esp. Chapters 23+25) • H. Barendregt, W. Dekkers, R. Statman: Lambda Calculus with Types. CUP 2013.	**2,00 Weekly Contact Hours**
2. Functional Programming of Reactive Systems **Mode of Delivery:** Practicals **Lecturers:** Prof. Ph.D. Michael Mendler **Language:** English/German **Frequency:** every summer semester **Contents:** The tutorials deepen the students' understanding of the theoretical concepts and constructions covered in the lectures through practical exercises. Participants are given the opportunity to discuss their solutions to homework question sheets and sample solutions are presented by the tutors or lecturer for selected exercises. The tutorials also provide exam preparation. **Literature:**	**2,00 Weekly Contact Hours**

The literature will be announced in class. Here are some general pointers on FP languages and synchronous programming. • S. Marlow: The Haskell 2010 Language Report. https://www.haskell.org/onlinereport/haskell2010/ • V. Zsók, Z. Horváth, R. Plasmeijer: Central European Functional Programming School. Springer 2012. • S. Marlow: Parallel and Concurrent Programming in Haskell: Techniques for Multicore and Multithreaded Programming, O'Reilly 2013. • D. Syme, A. Granicz, A. Cisternino: Expert F#4.0, Apress 2015. • H. Barendregt, W. Dekkers, R. Statman: Lambda Calculus with Types. CUP 2013. • Benveniste, A. et al: The Synchronous Languages 12 years later. Proc. IEEE, Vol 91(1), January 2003. • Berry, G.: SCADE: Synchronous design and validation of embedded control software. In: Next Generation Design and Verification Methodologies for Distributed Embedded Control Systems. Proc. GM R&D Workshop, Bangalore, January 2007. pp. 19-33. • Potop-Butucaru et. al: The Synchronous Hypothesis and Synchronous Languages. In Richard Zurawski. *Embedded Systems Design and Verification*, CRC Press, pp.6-1-6-27, 2009.	
Examination Written examination / Duration of Examination: 90 minutes **Description:** The examination language is English. The form of examination is either oral (30 minutes) or written (90 minutes) depending on the number of participants. The form of examination will be determined at the beginning of the semester and announced in class.	

Examination Oral examination / Duration of Examination: 30 minutes **Description:** The examination language is English. The form of examination is either oral (30 minutes) or written (90 minutes) depending on the number of participants. The form of examination will be determined at the beginning of the semester and announced in class.	

Module GdI-GTI-B Machines and Languages *Grundlagen der Theoretischen Informatik*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Ph.D. Michael Mendler		
Contents: This course addresses the questions "what is a computation?" and "what is an algorithm?" and explores the capabilities and limitations of computers and programming languages as well as the implication of these for a practical computer scientist. It introduces the basic concepts and methods that underlie the mathematical study of computing machines and formal languages.		
Learning outcomes: At the end of this course the students should be able to distinguish finite automata, pushdown automata, Turing machines, and know the difference between the deterministic and non-deterministic versions in each case; be able to distinguish regular, context-free, context-sensitive and general phrase structure grammars in the Chomsky Hierarchy; understand the relations between language classes and machine classes; have developed elementary automata and Turing machine programming skills; know the basic concepts of algorithmic complexity theory such as the big-O notation and key complexity classes such as N and NP as well as their relationship.		
Remark: The language of instruction in this course is German. However, all course materials (lecture slides and tutorial notes) as well as the exam are available in English.		
prerequisites for the module: None.		
Recommended prior knowledge: Elementary concepts in logic and discrete mathematics for computer scientists; Basic programming skills; English language skills at Level B2 (UniCert II) or above. Module Introduction to Algorithms, Programming and Software (DSG-EiAPS-B) - Module Propositional and Predicate Logic (GdI-MfI-1) - recommended		**Admission requirements:** None.
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Machines and Languages **Mode of Delivery:** Lectures **Lecturers:** Prof. Ph.D. Michael Mendler **Language:** German/English **Frequency:** every summer semester **Contents:** Through prepared class presentations and direct interactions with the students the lecturer introduces the topics of the course in detail, poses exercises and suggests literature for self-study.	**2,00 Weekly Contact Hours**

Literature: • Hopcroft, J. E., Motwani, R., Ullman, J. D.: Introduction to Automata Theory, Languages, and Computation. Addison Wesley, 2001. • Martin, J. C.: Introduction to Languages and the Theory of Computation, McGraw Hill, (2nd ed.), 1997. • Sudkamp, Th. A.: Languages and Machines. An Introduction to the Theory of Computer Science. Addison Wesley, (2nd ed.) 1997.	
2. Machines and Languages **Mode of Delivery:** Practicals **Lecturers:** Prof. Ph.D. Michael Mendler, N.N. **Language:** English/German **Frequency:** every summer semester **Contents:** The tutorials deepen the students' understanding of the theoretical concepts and constructions covered in the lectures through practical exercises. Participants are given the opportunity to present their solutions to homework question sheets and sample solutions are given by the lecturer for selected exercises. The tutorials also provide exam preparation.	**2,00 Weekly Contact Hours**
Examination Written examination / Duration of Examination: 90 minutes **Description:** 90 min written examination. The exam takes place during the regular exam period after the end of the semester. An alternative oral exam may be negotiable for guest students only.	

Module GdI-IFP-M Introduction to Functional Programming *Introduction to Functional Programming*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Ph.D. Michael Mendler		
Contents: The aim of this module is to provide an introduction to functional programming using Haskell. This course develops both elementary practical programming skills and discusses the typed lambda calculus and its role as an operational semantics for functional programming, stressing the importance of types and type checking for static program analysis.		
Learning outcomes: At the end of this course students should be familiar with important language constructs of Haskell and their semantics (e.g., expressions, local declarations, higher-order function abstraction, recursion, lazy and eager evaluation, referential transparency, algebraic data types, monads); be able to use these language concepts to solve algorithmic problems; be familiar with the lambda calculus as an operational semantics behind functional programming; understand the difference between imperative and declarative programming styles; have an appreciation of the close relationship between programming language types and specification and the role of type checking as a static program analysis method; be familiar with polymorphic Hindley-Milner style type systems.		
Remark: The main language of instruction in this course is English. However, the lectures and/or tutorials may be delivered in German if all participating students are fluent in German.		
prerequisites for the module: none		
Recommended prior knowledge: Elementary concepts in logic and discrete mathematics for computer scientists; Basic programming skills; English language skills at Level B2 (UniCert II) or above.		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Introduction to Functional Programming **Mode of Delivery:** Lectures **Lecturers:** Prof. Ph.D. Michael Mendler **Language:** English/German **Frequency:** every winter semester **Contents:** Through prepared class presentations and direct interactions with the students the lecturer introduces the topics of the course in detail, poses exercises and suggests literature for self-study. **Literature:** • Pierce, B. C.: Types and Programming Languages, MIT Press, 2002	**2,00 Weekly Contact Hours**

• Thompson, S.: Haskell – The Craft of Functional Programming, Addison-Wesley 1999.	
2. Introduction to Functional Programming **Mode of Delivery:** Practicals **Lecturers:** Prof. Ph.D. Michael Mendler **Language:** English/German **Frequency:** every winter semester **Contents:** The tutorials deepen the students' understanding of the theoretical concepts and constructions covered in the lectures through practical exercises. Participants are given the opportunity to discuss their solutions to homework question sheets and sample solutions are presented by the tutors or lecturer for selected exercises. The tutorials also provide exam preparation.	**2,00 Weekly Contact Hours**
Examination Written examination / Duration of Examination: 90 minutes **Description:** 90 min written examination. The exam takes place during the regular exam period after the end of the semester.	

Module GdI-MTL-B Modal and Temporal Logic *Modal and Temporal Logic*	6 ECTS / 180 h

(since WS24/25)
Person responsible for module: Prof. Ph.D. Michael Mendler

Contents:
This advanced module aims to give a thorough introduction to a selection of modal logics with strong applications in Computer Science. Basic knowledge of classical propositional logic and predicate logic and associated calculi is assumed as a prerequisite. Among the logics covered are modal and temporal logics for the analysis of distributed systems or semantic information processing. Depending on the time available, the module also covers belief logics and other specialised logics for security protocols and distributed algorithms. The course addresses theoretical foundations (models and proof systems) but also discusses applications and offers practical experience through hands-on experimentation with automatic and interactive verification tools.

Learning outcomes:
At the end of the course students should understand the commonalities and differences between propositional and predicate logics on the one hand and modal logics on the other for system specification and modelling; be aware of the important role played by modal logics for the trade-off between expressiveness and automation; know the semantical foundations of modal logics based on Kripke structures; understand the difference between epistemic, temporal, deontic modalities; be familiar with basic results from modal correpondence theory with modal theories such as K, S4, S5; know the Hennessy-Milner Theorem, model filtration and minimzation techniques; apply standard reasoning procedures based on Hilbert, Gentzen Sequent and Tableau calculi; be familiar with the syntax and semantics of important temporal logics such as PLTL, CTL and description logics such as ALC; be able to apply deduction and model-checking techniques for the specification and verification of distributed and dynamic systems as well as semantic information processing.

Remark:
The main language of instruction in this course is English. However, the lectures and/or tutorials may be delivered in German if all participating students are fluent in German.

prerequisites for the module:
none

Recommended prior knowledge: Elemantary logic and discrete mathematics for computer scientists; Basic programming skills. Module Discrete Modeling (Inf-DM-B) - recommended Module Logic and Computability (Inf-LBR-B) - recommended		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units

Modal and Temporal Logic **Mode of Delivery:** Lectures and Practicals **Lecturers:** Prof. Ph.D. Michael Mendler **Language:** English/German	**4,00 Weekly Contact Hours**

Frequency: every winter semester

Contents:

Through prepared class presentations and direct interactions with the students the lecturer introduces the topics of the course in detail, poses exercises and suggests literature for self-study.

Literature:

- Fagin, R., Halpern, J. Y., Moses, Y., Vardi, M. Y.: Reasoning about Knowledge. MIT Press, (2nd printing) 1996.
- Hughes, G. E., Cresswell, M. J.: A New Introduction to Modal Logic. Routledge, (3rd reprint) 2003.
- Popkorn, S.: First Steps in Modal Logic. Cambridge University Press, 1994.
- Baader, F., Calvanese, D., McGuinness, D.L., Nardi, D., Patel-Schneider, P.F. (eds): The Description Logic Handbook: Theory, Implementation and Applications. Cambridge University Press, (2nd ed.) 2007.

Examination

Oral examination

Description:

The examination language is English.

The form of examination is either oral (30 minutes) or written (90 minutes) depending on the number of participants. The form of examination will be determined at the beginning of the semester and announced in class.

Module GdI-Proj-B Foundations of Computing Project *Bachelorprojekt Grundlagen der Informatik*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Ph.D. Michael Mendler		
Contents: The project will be conducted either individually or in small student teams depending on the topic which will fall into one of the current active research areas of the informatics theory group (GDI). The results of the project are documented in written form in a work report and orally presented in a research talk. The project typically consists of theoretical research based on the literature and some software implementation.		
Learning outcomes: By conducting supervised research the project implementation work, the students will be able to gain an understanding of further central issues in the theory of computing, beyond the contents covered in regular modules. They will also be able to deepen their knowledge of the practical application of theoretical concepts discussed in theory modules they have previously attended and develop important research skills.		
Remark: The written reports and the presentation may be delivered in English or in German.		
prerequisites for the module: none		
Recommended prior knowledge: Students are expected to possess general skills and knowledge in the planning, organisation and execution of software projects, such as acquired in a previous software engineering lab module. Typically, students have previously also attended courses on research methods. In addition, for projects in the theoretical foundations of computer science we strongly recommend: a good command of English, elementary formal logic, basic knowledge in the theory of machines and languages, computer architecture, operating systems, non-procedural programming. Module Modal and Temporal Logic (GdI-MTL-B) - recommended Module Discrete Modeling (Inf-DM-B) - recommended Module Logic and Computability (Inf-LBR-B) - recommended		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Project Tutorials **Mode of Delivery:** **Language:** English/German **Frequency:** every semester	**4,00 Weekly Contact Hours**
Contents: Project planning meetings, tutorials on the topics of the project, final report and poster presentation	

Literature: Literatur wird bei Ankündigung bzw. zu Beginn des Projektes bekanntgegeben.	

Examination Coursework Assignment and Colloquium / Duration of Examination: 20 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regelmäßige Teilnahme an der Lehrveranstaltung **Description:** Darstellung der Projektergebnisse in einer Hausarbeit und deren Verteidigung in einem Kolloquium. Die Prüfungssprache wird in der ersten Lehrveranstaltung bekanntgegeben.	

Module GdI-Proj-M Master's Project Theoretical Foundations of Computing *Masterprojekt Grundlagen der Informatik*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Ph.D. Michael Mendler		
Contents: The project will be conducted either individually or in small student teams depending on the topic which will fall into one of the current active research areas of the informatics theory group (GDI). The results of the project are documented in written form in a work report and orally presented in a research talk. The project typically consist of theoretical research based on the literature and some software implementation.		
Learning outcomes: By conducting supervised research the project implementation work, the students will be able to gain an understanding of further central issues in the theory of computing, beyond the contents covered in regular modules. They will also be able to deepen their knowledge of the practical application of theoretical concepts discussed in theory modules they have previously attended and develop important research skills.		
prerequisites for the module: none		
Recommended prior knowledge: Students are expected to possess general skills and knowledge in the planning, organisation and execution of software projects, such as acquired in a previous software engineering lab module. Typically, students have previously also attended courses on research methods. In addition, for projects in the theoretical foundations of computer science we strongly recommend: a good command of English, elementary formal logic, basic knowledge in the theory of machines and languages, computer architecture, operating systems, non-procedural programming. Module Functional Programming of Reactive Systems (GdI-FPRS-M) - recommended Module Introduction to Functional Programming (GdI-IFP-M) - recommended		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Master's Project Theoretical Foundations of Computing **Mode of Delivery:** **Lecturers:** Prof. Ph.D. Michael Mendler **Language:** English/German **Frequency:** every semester	**4,00 Weekly Contact Hours**
Learning outcome: To be announced at the beginning of the semester.	
Contents:	

Project planning meetings, tutorials on the project topics, final presentation and poster **Literature:** Relevant literature will be announced at the beginning of the semester.	
Examination Coursework Assignment and Colloquium / Duration of Examination: 20 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regelmäßige Teilnahme an der Lehrveranstaltung **Description:** Preparation of the final written project report and poster presentation with colloquium.	

Module GdI-Sem-B Seminar Foundations of Computing *Bachelorseminar Grundlagen der Informatik*		3 ECTS / 90 h
(since WS17/18) Person responsible for module: Prof. Ph.D. Michael Mendler		
Contents: Im Seminarmodul werden wechselnde Themen im Bereich der Informatikgrundlagen angeboten.		
Learning outcomes: Fähigkeit zur selbständigen Erarbeitung von Inhalten aus der aktuellen wissenschaftlichen Literatur; Fähigkeit, komplexe Problemlösungsansätze schriftlich und mündlich zu vermitteln. Förderung der wissenschaftliche Neugier und die Ausbildung einer selbstbewussten und forschenden Einstellung zur Technik.		
Remark: The written seminar essay and the presentation may be delivered in English or in German.		
prerequisites for the module: none		
Recommended prior knowledge: Mathematik für Informatiker, Einführung in die Informatik, Rechner- und Betriebssysteme, Grundlagen der Theoretischen Informatik, gute Englischkenntnisse.		**Admission requirements:** none
Frequency: winter and summer semester, on demand	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Grundlagen der Informatik **Mode of Delivery:** Seminar **Lecturers:** Michael Mendler, N.N. **Language:** English/German **Frequency:** winter and summer semester, on demand **Contents:** Das GdI-Seminar wird zu semesterweise wechselnden Themen angeboten. Die Lehrsprache wird in der ersten Lehrveranstaltung bekanntgegeben. **Literature:** Literatur wird bei Ankündigung bzw. zu Beginn des Seminars bekanntgegeben.	**2,00 Weekly Contact Hours**
Examination Coursework Assignment with presentation / Duration of Examination: 30 minutes Duration of Coursework: 4 months **prerequisites for module examination:** regelmäßige Teilnahme an der Lehrveranstaltung **Description:** Die Prüfungssprache wird in der ersten Lehrveranstaltung bekanntgegeben.	

Module GdI-Sem-M Master's Seminar Theoretical Computer Science *Masterseminar Grundlagen der Informatik*		3 ECTS / 90 h
(since WS17/18) Person responsible for module: Prof. Ph.D. Michael Mendler		
Contents: The GdI seminar will be held on a semesterly basis on varying topics in the area of theoretical foundations of computer science.		
Learning outcomes: Ability to develop problem solutions from independent research into the current academic literature, specifically with focus on mathematical tools; Ability to communicate complex problem-solving approaches in writing and orally. Promotion of the scientific curiosity and the formation of a self-confident research attitude towards Computer Science Engineering.		
Remark: The written seminar essay and the presentation may be delivered in English or in German.		
prerequisites for the module: none		
Recommended prior knowledge: Discrete Mathematics, elementary Logic and Algebra. Introduction to Theoretical Computer Sciences, Functional Programming; Distributed Systems; English language skills at level B2 (UniCert II) or above.		**Admission requirements:**
Frequency: winter or summer semester, on demand	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Master's Seminar Theoretical Computer Science **Mode of Delivery:** Seminar **Lecturers:** Michael Mendler, N.N. **Language:** English/German **Frequency:** winter or summer semester, on demand **Contents:** The GdI seminar will be held on a semesterly basis on varying topics in the area of theoretical foundations of computer science. **Literature:** Pertinent literature will be selected and announced during the first classes at the beginning of the semester.	**2,00 Weekly Contact Hours**
Examination Coursework Assignment with presentation / Duration of Examination: 30 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regelmäßige Teilnahme an der Lehrveranstaltung **Description:**	

The examination language will be announced in the first course.	

Module HCI-DFM-M Design and Research Methods of Human-Computer Interaction *Design- und Forschungsmethoden der Mensch-Computer-Interaktion*		6 ECTS / 180 h
(since SS24) Person responsible for module: Prof. Dr. Tom Gross		
Contents: Advanced theoretical, methodological, and practical foundation of Human-Computer Interaction		
Learning outcomes: The aim of this module is to teach advanced knowledge and skills in the area of human-computer interaction as well as a broad theoretical and practical methodological expertise concerned with the design, conception, and evaluation of ubiquitous systems. Students of this course learn the relevant literature and systems in breadth and depth and are later able to critical review new literature and systems.		
Remark: http://www.uni-bamberg.de/hci/leistungen/studium The workload for this module is roughly structured as following: • Attendance of the lectures and assignments: 45 hours • Credits of the lecture (incl. research and study of additional sources): ca. 30 hours • Credits of the assignments (incl. research and study of additional sources, but without optional homework assignment): ca. 30 hours • Solving the optional homework assignments: overall ca. 45 hours • Exam preparation: ca. 30 hours (based on the above mentioned preparation and revision of the subject material) The default language of instruction in this course is German, but can be changed to English on demand. All course materials (incl. exams) are available in English.		
prerequisites for the module: none		
Recommended prior knowledge: Module Algorithms and data structures (MI-AuD-B) Module Introduction to Algorithms, Programming and Software (DSG-EiAPS-B)		**Admission requirements:** Passing the written exam
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Human - Computer Interaction **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Tom Gross **Language:** German/English **Frequency:** every summer semester **Contents:** After an introduction into the subject the following topics are covered in this lecture:	**2,00 Weekly Contact Hours**

- Mobile human-computer interaction
- Adaptivity and adaptibility
- Information visualisation
- Tangible user interaction
- Usability engineering
- Usability and economics

Literature:
The course is based on a compilation of different sources; as additional sources and as a reference are recommended:

- Jacko, J.A. and Sears, A., (Eds.). Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications. Lawrence Erlbaum, Hillsdale, NJ, 2002.
- Hammond, J., Gross, T. and Wesson, J., (Eds.). Usability: Gaining a Competitive Edge. Kluwer Academic Publishers, Dordrecht, 2002.

Examination
Oral examination
Description:
The oral exam takes 30 minutes and is worth a total of 90 points. Depending on the number of attendees the form of the exam can be changed to a written exam with 90 minutes and a total of 90 points. The final form of the exam is announced in the first lecture at the beginning of the term.

During the semester students can do assignments, which are optional. They are 12 points in total. The type of optional homework assignments as well as the deadlines are announced in detail at the beginning of the term. If the oral exam is passed (as a rule 50% of the points have to be reached) the points from the assignments are a bonus and added to the points from the oral exam. In any case, a top grade of 1,0 is also reachable without solving the assignments.

Module Units

Human-Computer Interaction **Mode of Delivery:** Practicals **Lecturers:** Scientific Staff Mensch-Computer-Interaktion **Language:** German/English **Frequency:** every summer semester **Contents:** Practical assignments based on the subjects of the lecture. **Literature:** Cf. lecture	**2,00 Weekly Contact Hours**

Examination
Written examination / Duration of Examination: 90 minutes
Description:

In Abhängigkeit von der Teilnehmerzahl wird die Modulprüfung entweder in Form einer Klausur oder in Form einer mündlichen Prüfung durchgeführt. Die Festlegung erfolgt zu Semesterbeginn und wird im ersten Lehrveranstaltungstermin bekannt gegeben. In der Klausur über 90 min. können 90 Punkte erzielt werden. Es besteht die Möglichkeit, optionale Studienleistungen zu erbringen. Diese umfassen insgesamt 12 Punkte. Die Art der optionalen Studienleistungen sowie deren Bearbeitungsfrist werden zu Beginn der Lehrveranstaltung verbindlich bekannt gegeben. Ist die Prüfung bestanden (in der Regel sind hierzu 50 % der Punkte erforderlich), so werden die durch optionale Studienleistungen erreichten Punkte als Bonuspunkte angerechnet. Eine 1,0 ist in der Prüfung auf jeden Fall auch ohne Punkte aus der Bearbeitung optionaler Studienleistungen erreichbar.	

Module HCI-DISTP-B Design of Interactive Systems: Theory and Practice *Design Interaktiver Systeme: Theorie und Praxis*		6 ECTS / 180 h
(since SS24) Person responsible for module: Prof. Dr. Tom Gross		
Contents: Theoretical, methodical, practical foundation of design and practical design with focus on a research challenge.		
Learning outcomes: The aim of this module is a general introduction to basic practical skills, processes, and methods of design with a special application-oriented focus on the user-centred design of complex interactive systems.		
Remark: http://www.uni-bamberg.de/hci/leistungen/studium The workload for this module is roughly structured as following: • Attendance of the lecture units • Participation in the group meetings • Work on the tasks alone and with the team • Preparation of discussions and presentation • Exam preparation The workload for each participant may vary over the different tasks based on the task definitions and the joint coordination of tasks in the team The default language of instruction is German and can be changed to English based on students' needs. All course materials (incl. exams) are available in English		
prerequisites for the module: none		
Recommended prior knowledge: none		**Admission requirements:**
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Design of Interactive Systems: Theory and Practice **Mode of Delivery:** Lectures and Practicals **Lecturers:** Jochen Denzinger **Language:** German/English **Frequency:** every summer semester **Contents:** In this lecture the following topics are covered: • Design theory and history • Design of multimodal user interfaces • User-Centred Design, User-Experience Design • Practical design, incl. practical application of methods for the iterative design	**1,00 Weekly Contact Hours**

The assignements cover diverse topics based on the contents of the course.
The practical part includes an iterative design as an assignment. The task is significantly more comprehensive than the normal assignments accompanying the lectures and therefore is solved in a small group. The results are documented and demonstrated in a final presentation.

Literature:
The course is based on a compilation of different sources; as additional sources and as a reference are recommended:

- Krippendorff, K. The Semantic Turn. A New Foundation for Design. Taylor & Francis Group, Boca Raton, FL, 2006.
- Moggridge, B. Designing Interactions. MIT Press, Cambridge, MA, 2007.

Examination
Colloquium / Duration of Examination: 30 minutes
Description:
Colloquium on the assignment process and results

Module Units

Reflexion zum Design interaktiver Systeme: Theorie und Praxis **Mode of Delivery:** Practicals **Lecturers:** Jochen Denzinger **Language:** German/English **Frequency:** every summer semester **Contents:** In der Übung erlernen die Studierenden die kritische Reflexion der eigenen Bearbeitung der wechselnden Aufgaben zu den Inhalten der Lehrveranstaltung im Rahmen des eigenen iterativen Entwurfs. **Literature:** Die Veranstaltung ist eine Zusammenstellung verschiedener Quellen	**1,00 Weekly Contact Hours**

Examination
Colloquium / Duration of Examination: 30 minutes
Description:
Kolloquium zum Übungsverlauf und Übungsergebnissen

Module HCI-IS-B Interactive Systems *Interaktive Systeme*	6 ECTS / 180 h 45 h Präsenzzeit 135 h Selbststudium

(since SS23)
Person responsible for module: Prof. Dr. Tom Gross

Contents:
Theoretical, methodological, and practical foundation of Human-Computer Interaction

Learning outcomes:
The aim of this module is a general introduction to fundamental paradigms, concepts, and principles of user interface design. The primary focus is on the conceptual design, the implementation, and the evaluation of interactive systems

Remark:
http://www.uni-bamberg.de/hci/leistungen/studium

The workload for this module is roughly structured as following:

- Attendance of the lectures and assignments: 45 hours
- Preparation and postprocessing of the lecture (incl. research and study of additional sources): ca. 30 hours
- Preparation and postprocessing of the assignments (incl. research and study of additional sources, but without homework assignment): ca. 30 hours
- Solving the optional homework assignments: overall ca. 45 hours
- Exam preparation: ca. 30 hours (based on the above mentioned preparation and revision of the subject material)

The default language of instruction is German and can be changed to English based on students' needs. All course materials (incl. exams) are available in English

prerequisites for the module:
none

Recommended prior knowledge: Basic knowledge in computer science to the extent of an introduction to computer science		**Admission requirements:** Passing the exam
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units

1. Interactive Systems **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Tom Gross **Language:** German/English **Frequency:** every winter semester	**2,00 Weekly Contact Hours**

Contents:
In this lecture the following topics are covered:

- Introduction to the design of user interfaces
- Human factors
- Technological factors

• Interaction, design, prototyping, and implementation • Evaluation of interactive systems • Design process of interactive systems • Interactive systems in a broader context and related topics **Literature:** The course is based on a compilation of different sources; as additional sources and as a reference are recommended: • Preece, J., Rogers, Y. and Sharp, H. Interaction Design: Beyond Human-Computer Interaction. Wiley, New York, NY, 3rd Edition, 2011. • Dix, A., Finlay, J., Abowd, G.D. and Beale, R. Human-Computer Interaction. Pearson, Englewood Cliffs, NJ, 3rd Edition, 2004.	
2. Interactive Systems **Mode of Delivery:** Practicals **Lecturers:** Scientific Staff Mensch-Computer-Interaktion **Language:** German/English **Frequency:** every winter semester **Contents:** Practical assignments based on the subjects of the lecture including the programming of small prototypes **Literature:** Cf. lecture	**2,00 Weekly Contact Hours**
Examination Written examination / Duration of Examination: 90 minutes **Description:** The written exam is worth a total of 90 points During the semester students can do assignments, which are optional. They are 12 points in total. The type, effort and amount of points of optional homework assignments as well as the deadlines are announced in detail at the beginning of the term. If the written exam is passed (as a rule 50% of the points have to be reached) the points from the assignments are a bonus and added to the points from the written exam. In any case, a top grade of 1,0 is also reachable without solving the assignments.	

Examination Oral examination **Description:** In Abhängigkeit der Teilnehmerzahl wird die Modulprüfung entweder in Form einer Klausur oder in Form einer mündlichen Prüfung durchgeführt. Die Festlegung erfolgt zu Semesterbeginn und wird im ersten Lehrveranstaltungstermin bekannt gegeben. In der mündlichen Prüfung können 90 Punkte erzielt werden. Die Prüfungsdauer wird im ersten Veranstaltungstermin mitgeteilt.	

Es besteht die Möglichkeit, optionale Studienleistungen zu erbringen. Diese umfassen insgesamt 12 Punkte. Die Art der optionalen Studienleistungen sowie deren Bearbeitungsfrist werden zu Beginn der Lehrveranstaltung verbindlich bekannt gegeben. Ist die Prüfung bestanden (in der Regel sind hierzu 50 % der Punkte erforderlich), so werden die durch optionale Studienleistungen erreichten Punkte als Bonuspunkte angerechnet. Eine 1,0 ist in der Prüfung auf jeden Fall auch ohne Punkte aus der Bearbeitung optionaler Studienleistungen erreichbar.	

Module HCI-KS-B Cooperative Systems *Kooperative Systeme*	6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Tom Gross	

Contents:
Theoretical, methodological, and practical foundation of Computer-Supported Cooperative Work.

Learning outcomes:
The aim of this module is to teach advanced paradigms and concepts of computer-supported cooperative work (CSCW) and the resulting design principles and prototypes. Hereby a broad perspective on the topic is applied; accordingly a central concern is the general technological support of social interaction, spanning cooperative work and learning as well as leisure activities.

Remark:
http://www.uni-bamberg.de/hci/leistungen/studium

The workload for this module is roughly structured as following:

- Attendance of the lectures and assignments: 45 hours
- Credits of the lecture (incl. research and study of additional sources): ca. 30 hours
- Credits of the assignments (incl. research and study of additional sources, but without optional homework assignment): ca. 30 hours
- Solving the optional homework assignments: overall ca. 45 hours
- Exam preparation: ca. 30 hours (based on the above mentioned preparation and revision of the subject material)

The default language of instruction is German and can be changed to English based on students' needs. All course materials (incl. exams) are available in English

prerequisites for the module:
none

Recommended prior knowledge: Basic knowledge in computer science to the extent of an introduction to algorithms, programming and software, as well as programming skills in Java.		**Admission requirements:** Passing the written exam
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Cooperative Systems **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Tom Gross **Language:** German/English **Frequency:** every summer semester	**2,00 Weekly Contact Hours**
Contents: After an introduction into the subject the following topics are covered in this lecture: • Basic concepts	

- Technological support for mutual awareness, communication, coordination, collaboration, and online communities
- Analysis of cooperative environments
- Design of CSCW and groupware systems
- Implementation of CSCW and groupware systems
- CSCW in a broader context and related topics

Literature:
The course is based on a compilation of different sources; as additional sources and as a reference are recommended:

- Gross, T. and Koch, M. Computer-Supported Cooperative Work (Computer-Supported Cooperative Work; in German). Oldenbourg, Munich, 2007.
- Borghoff, U.M. and Schlichter, J.H. Computer-Supported Cooperative Work: Introduction to Distributed Applications. Springer-Verlag, Heidelberg, 2000.

Examination
Oral examination
Description:
The oral exam takes 30 minutes and is worth a total of 90 points. Depending on the number of attendees the form of the exam can be changed to a written exam with 90 minutes and a total of 90 points. The final form of the exam is announced in the first lecture at the beginning of the term.

During the semester students can do assignments, which are optional. They are 12 points in total. The type of optional homework assignments as well as the deadlines are announced in detail at the beginning of the term. If the oral exam is passed (as a rule 50% of the points have to be reached) the points from the assignments are a bonus and added to the points from the oral exam. In any case, a top grade of 1,0 is also reachable without solving the assignments.

Module Units	
Cooperative Systems **Mode of Delivery:** Practicals **Lecturers:** Scientific Staff Mensch-Computer-Interaktion **Language:** German/English **Frequency:** every summer semester **Contents:** Practical assignments based on the subjects of the lecture including the programming of small prototypes **Literature:** Cf. lecture	**2,00 Weekly Contact Hours**

Examination
Written examination / Duration of Examination: 90 minutes
Description:

In Abhängigkeit der Teilnehmerzahl wird die Modulprüfung entweder in Form einer Klausur oder in Form einer mündlichen Prüfung durchgeführt. Die Festlegung erfolgt zu Semesterbeginn und wird im ersten Lehrveranstaltungstermin bekannt gegeben. In der Klausur über 90 min. können 90 Punkte erzielt werden. Es besteht die Möglichkeit, optionale Studienleistungen zu erbringen. Diese umfassen insgesamt 12 Punkte. Die Art der optionalen Studienleistungen sowie deren Bearbeitungsfrist werden zu Beginn der Lehrveranstaltung verbindlich bekannt gegeben. Ist die Prüfung bestanden (in der Regel sind hierzu 50 % der Punkte erforderlich), so werden die durch optionale Studienleistungen erreichten Punkte als Bonuspunkte angerechnet. Eine 1,0 ist in der Prüfung auf jeden Fall auch ohne Punkte aus der Bearbeitung optionaler Studienleistungen erreichbar.	

Module HCI-MCI-M Human-Computer Interaction *Mensch-Computer-Interaktion*		6 ECTS / 180 h
(since WS21/22) Person responsible for module: Prof. Dr. Tom Gross		
Contents: Advanced theoretical, methodological, and practical foundation of Human-Computer Interaction		
Learning outcomes: The aim of this module is to teach advanced knowledge and skills in the area of human-computer interaction as well as a broad theoretical and practical methodological expertise concerned with the design, conception, and evaluation of ubiquitous systems. Students of this course learn the relevant literature and systems in breadth and depth and are later able to critical review new literature and systems.		
Remark: http://www.uni-bamberg.de/hci/leistungen/studium The workload for this module is roughly structured as following: • Attendance of the lectures and assignments: 45 hours • Credits of the lecture (incl. research and study of additional sources): ca. 30 hours • Credits of the assignments (incl. research and study of additional sources, but without optional homework assignment): ca. 30 hours • Solving the optional homework assignments: overall ca. 45 hours • Exam preparation: ca. 30 hours (based on the above mentioned preparation and revision of the subject material) The default language of instruction in this course is German, but can be changed to English on demand. All course materials (incl. exams) are available in English.		
prerequisites for the module: none		
Recommended prior knowledge: Module Algorithms and data structures (MI-AuD-B) Module Introduction to Algorithms, Programming and Software (DSG-EiAPS-B)		**Admission requirements:** Passing the written exam
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Human - Computer Interaction **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Tom Gross **Language:** German/English **Frequency:** every winter semester **Contents:** After an introduction into the subject the following topics are covered in this lecture: • Mobile human-computer interaction	**2,00 Weekly Contact Hours**

• Adaptivity and adaptibility • Information visualisation • Tangible user interaction • Usability engineering • Usability and economics **Literature:** The course is based on a compilation of different sources; as additional sources and as a reference are recommended: • Jacko, J.A. and Sears, A., (Eds.). Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications. Lawrence Erlbaum, Hillsdale, NJ, 2002. • Hammond, J., Gross, T. and Wesson, J., (Eds.). Usability: Gaining a Competitive Edge. Kluwer Academic Publishers, Dordrecht, 2002.	
Examination Oral examination **Description:** The oral exam takes 30 minutes and is worth a total of 90 points. Depending on the number of attendees the form of the exam can be changed to a written exam with 90 minutes and a total of 90 points. The final form of the exam is announced in the first lecture at the beginning of the term. During the semester students can do assignments, which are optional. They are 12 points in total. The type of optional homework assignments as well as the deadlines are announced in detail at the beginning of the term. If the oral exam is passed (as a rule 50% of the points have to be reached) the points from the assignments are a bonus and added to the points from the oral exam. In any case, a top grade of 1,0 is also reachable without solving the assignments.	

Module Units	
Human-Computer Interaction **Mode of Delivery:** Practicals **Lecturers:** Scientific Staff Mensch-Computer-Interaktion **Language:** German/English **Frequency:** every winter semester **Contents:** Practical assignments based on the subjects of the lecture. **Literature:** Cf. lecture	**2,00 Weekly Contact Hours**

Examination Written examination / Duration of Examination: 90 minutes **Description:** In Abhängigkeit der Teilnehmerzahl wird die Modulprüfung entweder in Form einer Klausur oder in Form einer mündlichen Prüfung durchgeführt.	

Die Festlegung erfolgt zu Semesterbeginn und wird im ersten Lehrveranstaltungstermin bekannt gegeben. In der Klausur über 90 Min. können 90 Punkte erzielt werden. Es besteht die Möglichkeit, optionale Studienleistungen zu erbringen. Diese umfassen insgesamt 12 Punkte. Die Art der optionalen Studienleistungen sowie deren Bearbeitungsfrist werden zu Beginn der Lehrveranstaltung verbindlich bekannt gegeben. Ist die Prüfung bestanden (in der Regel sind hierzu 50 % der Punkte erforderlich), so werden die durch optionale Studienleistungen erreichten Punkte als Bonuspunkte angerechnet. Eine 1,0 ist in der Prüfung auf jeden Fall auch ohne Punkte aus der Bearbeitung optionaler Studienleistungen erreichbar.	

Module HCI-Proj-B Project Human-Computer Interaction *Projekt Mensch-Computer-Interaktion*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Tom Gross		
Contents: Practical work on a research topic of Human-Computer Interaction.		
Learning outcomes: Based on the knowledge and skills obtained in the human-computer interaction lectures and assignments a group of students will develop a small prototype based on current research topics. Central to this project is the development of skills regarding the implementation of systems as well as competencies regarding project management and teamwork.		
Remark: http://www.uni-bamberg.de/hci/leistungen/studium The workload for this module is roughly structured as following: • Participation in the kick-off meeting • Participation in the group meetings • Work on the project tasks alone and with the team • Preparation of project discussions and presentation • Exam preparation The workload for each participant may vary over the different tasks based on the project definition and the joint coordination of tasks in the team The default language of instruction in this course is German, but can be changed to English on demand. All course materials (incl. exams) are available in English		
prerequisites for the module: none		
Recommended prior knowledge: Module Algorithms and Data Structures (MI-AuD-B) Module Interactive Systems (HCI-IS-B)		**Admission requirements:** Passing the exam
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Project Human-Computer Interaction **Mode of Delivery:** **Lecturers:** Prof. Dr. Tom Gross, Scientific Staff Mensch-Computer-Interaktion **Language:** German/English **Frequency:** every winter semester **Contents:** The project covers diverse topics based on the contents of the courses. The project task is significantly more comprehensive than the normal assignments	**4,00 Weekly Contact Hours**

accompanying the lectures and therefore is solved in a small group. The results of the project are documented and demonstrated in a final presentation. **Literature:** To be announced in the course	
Examination Coursework Assignment and Colloquium / Duration of Examination: 30 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regelmäßige Teilnahme an der Lehrveranstaltung **Description:** Documentation on the development process and project results as well as colloquium on the development process and project results.	

Module HCI-Proj-M Project Human-Computer Interaction *Projektpraktikum Mensch-Computer-Interaktion*		6 ECTS / 180 h
(since SS24) Person responsible for module: Prof. Dr. Tom Gross		
Contents: Advanced practical work on a research topic of Human-Computer Interaction.		
Learning outcomes: Based on the knowledge and skills obtained in the human-computer interaction lectures and assignments a group of students develops a small prototype based on current research topics. Central to this project is the development of skills regarding the implementation of systems as well as competencies regarding project management and teamwork. Through the complexity of the task and the direct relation to on-going research at the human-computer interaction group this project is significantly different from the projects at Bachelor's level.		
Remark: http://www.uni-bamberg.de/hci/leistungen/studium The workload for this module is roughly structured as following: • Participation in the kick-off meeting • Participation in the group meetings • Work on the project tasks alone and with the team • Preparation of project discussions and presentation • Exam preparation The workload for each participant may vary over the different tasks based on the project definition and the joint coordination of tasks in the team The default language of instruction is German and can be changed to English based on students' needs. All course materials (incl. exams) are available in English.		
prerequisites for the module: none		
Recommended prior knowledge: Module Human-Computer Interaction (HCI-MCI-M) Module Algorithms and Data Structures (AI-AuD-B) - recommended		**Admission requirements:** Passing the exam
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Human-Computer Interaction **Mode of Delivery:** **Lecturers:** Prof. Dr. Tom Gross, Scientific Staff Mensch-Computer-Interaktion **Language:** German/English **Frequency:** every summer semester **Contents:**	**4,00 Weekly Contact Hours**

The project will cover varying topics based on the contents of the courses. As normally the aspects of several courses are relevant, teams of students that have visited different courses will supplement each other. The project task is significantly more comprehensive than the normal assignments accompanying the lectures and therefore is solved in a small group. The results of the project are documented and demonstrated in a final presentation. **Literature:** To be announced in the course	
Examination Coursework Assignment and Colloquium / Duration of Examination: 30 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regelmäßige Teilnahme an der Lehrveranstaltung **Description:** Documentation on the development process and project results as well as colloquium on the development process and project results.	

<table>
<tr><td colspan="2">Module HCI-Proj1-M Research-Project Human-Computer Interaction
Forschungsprojektpraktikum Mensch-Computer-Interaktion</td><td>15 ECTS / 450 h</td></tr>
<tr><td colspan="3">(since SS24)
Person responsible for module: Prof. Dr. Tom Gross</td></tr>
<tr><td colspan="3">Contents:
Advanced practical work on a research topic of Human-Computer Interaction with scientific methods.</td></tr>
<tr><td colspan="3">Learning outcomes:
Based on the knowledge and skills obtained in the human-computer interaction lectures and assignments a group of students work on a project on current research topics. Central to this project is the development of skills regarding the implementation of systems as well as competencies regarding project management and teamwork.

This research project addresses recent trends and is research oriented. The primary focus of this interaction project is on learning methods for the analysis, design, and technical realisation of interaction concepts.</td></tr>
<tr><td colspan="3">Remark:
The workload for this module is roughly structured as following:
Participation in the kick-off meeting
Participation in the group meetings
Work on the project tasks alone and with the team
Preparation of project discussions and presentation
Exam preparation
The workload for each participant may vary over the different tasks based on the project definition and the joint coordination of tasks in the team

The default language of instruction in this course is German, but can be changed to English on demand. All course materials (incl. exams) are available in English.</td></tr>
<tr><td colspan="3">prerequisites for the module:
none</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
Module Human-Computer Interaction (HCI-MCI-M)</td><td>Admission requirements:
Passing the exam</td></tr>
<tr><td>Frequency: every summer semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
1 Semester</td></tr>
</table>

<table>
<tr><td colspan="2">Module Units</td></tr>
<tr><td>Human-Computer Interaction
Mode of Delivery:
Lecturers: Prof. Dr. Tom Gross, Scientific Staff Mensch-Computer-Interaktion
Language: German/English
Frequency: every summer semester

Contents:
The project covers varying topics based on the contents of the courses. As normally the aspects of several courses are relevant, teams of students that have visited different courses will supplement each other. The project task is,</td><td>6,00 Weekly Contact Hours</td></tr>
</table>

according to the 15 ECTS, complex and challenging. The results of the project are documented and demonstrated in a final presentation.	
Literature: To be announced in the course	

Examination Coursework Assignment and Colloquium / Duration of Examination: 30 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regelmäßige Teilnahme an der Lehrveranstaltung **Description:** Documentation on the development process and project results as well as colloquium on the development process and project results. The exact schedule of the project’s homework and colloquium are announced at the beginning of the term.	

<table>
<tr><td colspan="2">Module HCI-Proj2-M Research-Project Human-Computer Interaction
Forschungsprojektpraktikum Mensch-Computer-Interaktion</td><td>15 ECTS / 450 h</td></tr>
<tr><td colspan="3">(since SS24)
Person responsible for module: Prof. Dr. Tom Gross</td></tr>
<tr><td colspan="3">Contents:
Advanced practical work on a research topic of Human-Computer Interaction with scientific methods.</td></tr>
<tr><td colspan="3">Learning outcomes:
Based on the knowledge and skills obtained in the human-computer interaction lectures and assignments a group of students work on a project on current research topics. Central to this project is the development of skills regarding the implementation of systems as well as competencies regarding project management and teamwork.

This research project addresses recent trends and is research oriented. The primary focus of this interaction project is on learning methods for the analysis, design, and technical realisation of interaction concepts.</td></tr>
<tr><td colspan="3">Remark:
The workload for this module is roughly structured as following:
• Participation in the kick-off meeting
• Participation in the group meetings
• Work on the project tasks alone and with the team
• Preparation of project discussions and presentation
• Exam preparation

The workload for each participant may vary over the different tasks based on the project definition and the joint coordination of tasks in the team

The default language of instruction in this course is German, but can be changed to English on demand. All course materials (incl. exams) are available in English.</td></tr>
<tr><td colspan="3">prerequisites for the module:
none</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
Module Human-Computer Interaction (HCI-MCI-M)</td><td>Admission requirements:
Passing the exam</td></tr>
<tr><td>Frequency: every winter semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
1 Semester</td></tr>
</table>

<table>
<tr><td colspan="2">Module Units</td></tr>
<tr><td>Human-Computer Interaction
Mode of Delivery:
Lecturers: Prof. Dr. Tom Gross, Scientific Staff Mensch-Computer-Interaktion
Language: German/English
Frequency: every winter semester
<hr>Contents:
The project covers varying topics based on the contents of the courses. As normally the aspects of several courses are relevant, teams of students that have visited different courses will supplement each other. The project task is,</td><td>6,00 Weekly Contact Hours</td></tr>
</table>

according to the 15 ECTS, complex and challenging. The results of the project are documented and demonstrated in a final presentation. **Literature:** To be announced in the course	

Examination Coursework Assignment and Colloquium / Duration of Examination: 30 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regelmäßige Teilnahme an der Lehrveranstaltung **Description:** Documentation on the development process and project results as well as colloquium on the development process and project results. The exact schedule of the project’s homework and colloquium are announced at the beginning of the term.	

Module HCI-Prop-M Propaedeutic: Human-Computer-Interaction *Propädeutikum Mensch-Computer-Interaktion*		3 ECTS / 90 h
(since WS24/25) Person responsible for module: Prof. Dr. Tom Gross		
Contents: Scientific foundation of the research field of Human-Computer Interaction		
Learning outcomes: The aim of this module is a general introduction to and teaching of fundamental paradigms and scientific methods of the organisation, the written documentation, oral presentation of research activities in Human-Computer Interaction. The primary focus is on domain-specific documentation and presentation of designs, prototypes, and user studies.		
Remark: http://www.uni-bamberg.de/hci/leistungen/studium The workload for this module is roughly structured as following: • Participation in the course meetings (theoretical foundation; practical case studies): ca. 30 hours • Working on the case studies: ca. 30 hours • Preparation of presentation: ca. 15 hours • Writing of term paper: ca. 15 hours The default language of instruction in this course is German, but can be changed to English on demand. All course materials (incl. exams) are available in English.		
prerequisites for the module: none		
Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Propaedeutic: Human-Computer-Interaction **Mode of Delivery:** **Lecturers:** Prof. Dr. Tom Gross, Scientific Staff Mensch-Computer-Interaktion **Language:** German/English **Frequency:** every winter semester **Contents:** This seminar is concerned with the documentation and presentation of current concepts, technologies, and tools and user studies of human-computer interaction. **Literature:** The course is based on a compilation of different sources; as additional sources and as a reference are recommended:	**3,00 Weekly Contact Hours**

Jacko, Julie A., ed. Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications. (3rd ed.). Lawrence Erlbaum, Hillsdale, NJ, 2012.	
Examination Internship report / Duration of Examination: 30 minutes Duration of Coursework: 4 months **Description:** Written term paper and presentation on the chosen topic by the participant, incl. discussion	

Module HCI-Sem-B Bachelor-Seminar Human-Computer Interaction *Bachelorseminar Mensch-Computer-Interaktion*		3 ECTS / 90 h
(since WS24/25) Person responsible for module: Prof. Dr. Tom Gross		
Contents: Active scientific work on current concepts, technologies and tools of Human-Computer Interaction		
Learning outcomes: The aim of this course is the acquisition of abilities to do research and presentation of topics in the field of human-computer interaction on basis of the existing literature. The focus lies on the development of skills that allow to critically and systematically review literature and to give presentations.		
Remark: http://www.uni-bamberg.de/hci/leistungen/studium The workload for this module is roughly structured as following: • Participation in the seminars (introduction to the topics, discussions, presentations): ca. 20 hours • Literature review and getting familiar with the topic: ca. 25 hours • Preparation of presentation: ca. 15 hours Writing of term paper: ca. 30 hours The default language of instruction is German and can be changed to English based on students' needs. All course materials (incl. exams) are available in English		
prerequisites for the module: none		
Recommended prior knowledge: Module Interactive Systems (HCI-IS-B)		**Admission requirements:** Passing the exam
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Human-Computer Interaction **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Tom Gross, Scientific Staff Mensch-Computer-Interaktion **Language:** German/English **Frequency:** every summer semester **Contents:** Based on the knowledge and skills obtained in the human-computer interaction lectures and assignments varying, current research topics are discussed in this seminar. Thereby, aspects of several courses are of relevance. **Literature:** To be announced at the beginning of the course	**2,00 Weekly Contact Hours**
Examination Internship report / Duration of Examination: 30 minutes Duration of Coursework: 4 months	

Description: Written term paper and presentation on the chosen topic by the participant, incl. discussion	

Module HCI-Sem-HCC-M Master-Seminar Human-Centred Computing *Masterseminar Human-Centred Computing*		3 ECTS / 90 h
(since WS24/25) Person responsible for module: Prof. Dr. Tom Gross		
Contents: Advanced active scientific work on own current concepts, technologies and tools of Human-Computer Interaction		
Learning outcomes: The aim of this course is the acquisition of abilities that allow the independent research and presentation of topics in the field of human-computer interaction on basis of the existing literature. The focus lies on the development of skills that allow to critically and systematically review literature in order to develop and present an own perspective.		
Remark: http://www.uni-bamberg.de/hci/leistungen/studium The workload for this module is roughly structured as following: • Participation in the seminars (introduction to the topics, discussions, presentations): ca. 20 hours • Literature review and getting familiar with the topic: ca. 25 hours • Preparation of presentation: ca. 15 hours • Writing of term paper: ca. 30 hours The default language of instruction is German and can be changed to English based on students' needs. All course materials (incl. exams) are available in English		
prerequisites for the module: none		
Recommended prior knowledge: Module Human-Computer Interaction (HCI-MCI-M)		**Admission requirements:** Passing the exam
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Human-Centred Computing **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Tom Gross, Scientific Staff Mensch-Computer-Interaktion **Language:** German/English **Frequency:** every summer semester **Contents:** This seminar is concerned with novel research methods in the fields of human-computer interaction, computer-supported cooperative work, and ubiquitous computing. **Literature:** To be announced at the beginning of the course	**2,00 Weekly Contact Hours**
Examination	

Internship report / Duration of Examination: 30 minutes Duration of Coursework: 4 months **Description:** Written term paper and presentation on the chosen topic by the participant, incl. discussion	

Module HCI-Sem-M Master-Seminar Human-Computer Interaction *Masterseminar Mensch-Computer-Interaktion*		3 ECTS / 90 h
(since WS24/25) Person responsible for module: Prof. Dr. Tom Gross		
Contents: Advanced active scientific work on current concepts, technologies and tools of Human-Computer Interaction		
Learning outcomes: The aim of this course is the acquisition of abilities that allow the independent research and presentation of topics in the field of human-computer interaction on basis of the existing literature. The focus lies on the development of skills that allow to critically and systematically review literature in order to develop and present an own perspective.		
Remark: http://www.uni-bamberg.de/hci/leistungen/studium The workload for this module is roughly structured as following: • Participation in the seminars (introduction to the topics, discussions, presentations): ca. 20 hours • Literature review and getting familiar with the topic: ca. 25 hours • Preparation of presentation: ca. 15 hours • Writing of term paper: ca. 30 hours The default language of instruction in this course is German, but can be changed to English on demand. All course materials (incl. exams) are available in English.		
prerequisites for the module: none		
Recommended prior knowledge: Module Human-Computer Interaction (HCI-MCI-M)		**Admission requirements:** Passing the exam
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Human-Computer Interaction **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Tom Gross, Scientific Staff Mensch-Computer-Interaktion **Language:** German/English **Frequency:** every winter semester **Contents:** This seminar is concerned with topics on current concepts, technologies, and tools of human-computer interaction. **Literature:** To be announced at the beginning of the course	**2,00 Weekly Contact Hours**
Examination Internship report / Duration of Examination: 30 minutes	

Duration of Coursework: 4 months **Description:** Written term paper and presentation on the chosen topic by the participant, incl. discussion	

Module HCI-US-B Ubiquitous Systems *Ubiquitäre Systeme*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Tom Gross		
Contents: Theoretical, methodological, and practical foundation of Ubiquitous Computing		
Learning outcomes: The aim of this module is to teach advanced knowledge and skills in the aerea of ubiquitous systems as well as abroad theoretical and practical methodological expertise concerned with the design, conception and evaluation of ubiquitous systems. Students of this course learn the relevant literature and systems in breadth and depth and should be able to critical review new litarature and systems		
Remark: htp://www.uni-bamberg.de/hci/leistungen/studium The workload for this module is roughly structured as following: • Attendance of the lectures and assignments: 45 hours • Credits of the lecture (incl.research and study of additional sources): ca. 30 Hours • Credits of the assignments ((incl.research and study of additional sources, excluding optional homework assignment): ca. 30 hours • Solving the optional homework assignments: overall ca. 45 hours • Exam preparation: ca. 30 hours (based on the above mentioned preparation and revision of the subject material) The default language of instruction in this course is German, but can be changed to English on demand. All course materials (incl. exams) are available in English.		
prerequisites for the module: none		
Recommended prior knowledge: Module Algorithms and data structures (MI-AuD-B) Module Introduction to Algorithms, Programming and Software (DSG-EiAPS-B)		**Admission requirements:** Passing the written exam
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Ubiquitous Systems **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Tom Gross **Language:** German/English **Frequency:** every winter semester **Contents:** This lecture gives an introduction to the subject of Ubiquitous Computing—that is, the paradigm of invisible computing, with computers embedded into everyday objects that act as client and server and communicate with each other—and includes the following conceptual, technical and methodological topics:	**2,00 Weekly Contact Hours**

• Basic concepts • Base technology and infrastructures • Ubiquitous systems and prototypes • Context awareness • User interaction • Ubiquitous systems in a broad context and related topics **Literature:** The course is based on a compilation of different sources; as additional sources and as a reference are recommended: • Krumm, J. (Ed.). Ubiquitous Computing Fundamentals. Taylor & Francis Group, Boca Raton, FL, 2010.	
Examination Oral examination **Description:** The oral exam takes 30 minutes and is worth a total of 90 points. Depending on the number of attendees the form of the exam can be changed to a written exam with 90 minutes and a total of 90 points. The final form of the exam is announced in the first lecture at the beginning of the term. During the semester students can do assignments, which are optional. They are 12 points in total. The type of optional homework assignments as well as the deadlines are announced in detail at the beginning of the term. If the oral exam is passed (as a rule 50% of the points have to be reached) the points from the assignments are a bonus and added to the points from the oral exam. In any case, a top grade of 1,0 is also reachable without solving the assignments.	

Module Units	
Ubiquitous Systems **Mode of Delivery:** Practicals **Lecturers:** Scientific Staff Mensch-Computer-Interaktion **Language:** German/English **Frequency:** every winter semester **Contents:** Practical assignments based on the subjects of the lecture including the programming of small prototypes **Literature:** Cf. lecture	**2,00 Weekly Contact Hours**

Examination Written examination / Duration of Examination: 90 minutes **Description:** In Abhängigkeit der Teilnehmerzahl wird die Modulprüfung entweder in Form einer Klausur oder in Form einer mündlichen Prüfung durchgeführt.	

Die Festlegung erfolgt zu Semesterbeginn und wird im ersten Lehrveranstaltungstermin bekannt gegeben. In der Klausur über 90 min. können 90 Punkte erzielt werden. Es besteht die Möglichkeit, optionale Studienleistungen zu erbringen. Diese umfassen insgesamt 12 Punkte. Die Art der optionalen Studienleistungen sowie deren Bearbeitungsfrist werden zu Beginn der Lehrveranstaltung verbindlich bekannt gegeben. Ist die Prüfung bestanden (in der Regel sind hierzu 50 % der Punkte erforderlich), so werden die durch optionale Studienleistungen erreichten Punkte als Bonuspunkte angerechnet. Eine 1,0 ist in der Prüfung auf jeden Fall auch ohne Punkte aus der Bearbeitung optionaler Studienleistungen erreichbar.	

Module HCI-Usab-M Usability in Practice *Usability in der Praxis*		6 ECTS / 180 h
(since WS17/18) Person responsible for module: Prof. Dr. Tom Gross		
Contents: Practical work on a real-world topic of Human-Computer Interaction.		
Learning outcomes: In this course the knowledge and skills obtained in the human-computer interaction lectures and assignments are applied in practice. Based on real use cases from industry contexts students will analyse the usability of existing concepts and systems and gather requirements for innovative concepts. Central to this course is the development of skills regarding the practical application of methods as well as competencies regarding project management and teamwork.		
Remark: http://www.uni-bamberg.de/hci/leistungen/studium The workload for this module is roughly structured as following: • Participation in the kick-off meeting • Participation in the group meetings • Work on the tasks alone and with the team • Preparation of discussions and presentation • Exam preparation The workload for each participant may vary over the different tasks based on the task definitions and the joint coordination of tasks in the team The default language of instruction is German and can be changed to English based on students' needs. All course materials (incl. exams) are available in English		
prerequisites for the module: none		
Recommended prior knowledge: Module Human-Computer Interaction (HCI-MCI-M)		**Admission requirements:** Passing the exam
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Usability in der Praxis **Mode of Delivery:** Practicals **Lecturers:** Prof. Dr. Tom Gross, Scientific Staff Mensch-Computer-Interaktion **Language:** German/English **Frequency:** every summer semester **Contents:** The course covers diverse topics from human-computer interaction that are cooperatively solved with companies. They typically range from specifying challenges to selecting and applying methods as well as analysing the captured data to deriving conclusions. The task is significantly more comprehensive than	**4,00 Weekly Contact Hours**

the normal assignments accompanying the lectures and therefore is solved in a small group. The results are documented and demonstrated in a final presentation. **Literature:** To be announced in the course	
Examination Coursework Assignment and Colloquium / Duration of Examination: 30 minutes Duration of Coursework: 4 months **prerequisites for module examination:** regelmäßige Teilnahme an der Lehrveranstaltung **Description:** Documentation on the project process and results as well as colloquium on the project process and results.	

Module IIS-Sem-B Bachelor Seminar Industrial Information Systems *Bachelorseminar Industrielle Informationssysteme*		3 ECTS / 90 h
(since WS17/18) Person responsible for module: Prof. Dr. Sven Overhage		
Contents: Seminar with changing topics in industrial information systems. The specific seminar topic will be announced by the examiner at the beginning of the winter semester.		
Learning outcomes: none		
Remark: The main language of instruction in this course is German. The exam may be delivered in English on demand.		
prerequisites for the module: none		
Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Bachelor Seminar Industrial Information Systems **Mode of Delivery:** Introductory seminar **Lecturers:** Prof. Dr. Sven Overhage **Language:** German **Frequency:** every winter semester **Contents:** The specific seminar topic will be announced by the examiner at the beginning of the winter semester.	**2,00 Weekly Contact Hours**

Examination	
Coursework Assignment with presentation / Duration of Examination: 30 minutes Duration of Coursework: 3 months	

Module IIS-Sem-M Master Seminar Industrial Information Systems *Masterseminar Industrielle Informationssysteme*		3 ECTS / 90 h
(since WS17/18) Person responsible for module: Prof. Dr. Sven Overhage		
Contents: Seminar with changing topics in industrial information systems. The specific seminar topic will be announced by the examiner at the beginning of the winter semester.		
Learning outcomes: none		
Remark: The main language of instruction in this course is German. The exam may be delivered in English on demand.		
prerequisites for the module: none		
Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Master Seminar Industrial Information Systems **Mode of Delivery:** Introductory seminar **Lecturers:** Prof. Dr. Sven Overhage **Language:** German **Frequency:** every winter semester **Contents:** The specific seminar topic will be announced by the examiner at the beginning of the winter semester.	**2,00 Weekly Contact Hours**

Examination Coursework Assignment with presentation / Duration of Examination: 30 minutes Duration of Coursework: 3 months	

Module ISDL-DEXP-B Digital Experimentation *Digital Experimentation*		6 ECTS / 180 h
Person responsible for module: Dr. Christoph Weinert		
Contents: Durch das Internet kamen sogenannte Online-Experiment auf, die gerade von großen Tech-Konzernen wie Google, Facebook oder Alibaba genutzt werden, um Produkte und Dienstleistungen zu evaluieren. Darüber hinaus können Experimente dabei helfen sozialen und wirtschaftlichen Aktivitäten, an denen sich Menschen online beteiligen besser zu verstehen. Das liegt daran, dass Experimente sowohl in der Forschung als auch in der Praxis eine exzellente Möglichkeit sind, um Reiz-Reaktions-Beziehungen abzubilden und untersuchen zu können. In einem Experiment wird ein Reiz bewusst manipuliert, um die darauffolgenden Reaktionen messen zu können während die Kontextvariablen stabil gehalten oder kontrolliert werden. Die Durchführung von Experimenten hat eine lange Historie in den Naturwissenschaften, allerdings wird diese Methode immer häufiger in die Praxis und Forschung der Wirtschaftsinformatik eingesetzt. Die Vorlesung gliedert sich ausgehend von generellen Einsatz von Experimenten in Forschung und Praxis bis hin zur konkreten Planung, Aufbau und Durchführung von verschiedenen Arten von Experimenten (z.B. Online-Experimente, Laborexperimente, Feldexperimente).		
Learning outcomes: Das Modul vermittelt ein grundlegendes Verständnis sowie Kenntnisse zu Planung, Aufbau, Durchführung, und Auswertung für verschiedene Arten von Experimenten (z.B. Online-Experimente, Laborexperimente, Feldexperimente). Das Modul befähigt die Teilnehmer zur eigenständigen Durchführung von Experimenten in wissenschaftlichen wie auch praktischen Kontexten.		
Remark: Der Arbeitsaufwand für dieses Modul gliedert sich ungefähr wie folgt: • Teilnahme an Vorlesung und Übung: insgesamt 42 Stunden • Vor- und Nachbereitung der Vorlesung und Übung (inkl. Recherche und Studium zusätzlicher Quellen): 56 Stunden • Bearbeiten der Übungsaufgaben: insgesamt 40 Stunden • Prüfungsvorbereitung ink. Prüfung: 42 Stunden (basierend auf dem bereits im obigen Sinne erarbeiteten Stoff)		
prerequisites for the module: keine		
Recommended prior knowledge: keine		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Experimentelle Forschung in der Wirtschaftsinformatik **Mode of Delivery:** Lectures and Practicals **Lecturers:** Dr. Christoph Weinert **Language:** German **Frequency:** every winter semester	**2,00 Weekly Contact Hours**

Contents: Die Inhalte der Vorlesung werden anhand von praktischen Beispielen vertieft. Die Studierenden bekommen die Möglichkeit ein eigenes Experiment zu planen, durchzuführen und auszuwerten. Hierbei werden unter anderem psychologische Tests und objektive Messmethoden (z.B. Eye-tracking, Skin conductance) genutzt.	
Literature: Jarvenpaa, S. L., Dickson, G. W., and DeSanctis, G. 1985. “Methodological Issues in Experimental IS Research: Experiences and Recommendations,” MIS Quarterly (9:2), pp. 141–156. Karahanna, E., Benbasat, I., Bapna, R., and Rai, A. 2018. “Opportunities and Challenges for Different Types of Online Experiments,” MIS Quarterly (42:4), pp. iii–x. Weitere Literatur wird in der Vorlesung bekannt gegeben.	

Examination Written examination / Duration of Examination: 90 minutes **prerequisites for module examination:** keine **Description:** In der Klausur werden die in der Vorlesung und Übung behandelten Inhalte geprüft. Es können 90 Punkte erzielt werden. Durch die freiwillige Abgabe von semesterbegleitenden Studienleistungen (Planung und Durchführung eines Experiments) können Punkte zur Notenverbesserung gesammelt werden, die auf die Klausur anrechenbar sind, sofern die Klausur auch ohne Punkte aus Studienleistungen bestanden ist. Zu Beginn der Lehrveranstaltung wird bekannt gegeben, ob Studienleistungen angeboten werden. Falls Studienleistungen angeboten werden, wird zu diesem Zeitpunkt auch die Anzahl, die Art, der Umfang und die Bearbeitungsdauer der Studienleistungen sowie die Anzahl an erreichbaren Punkten pro Studienleistung bekannt gegeben. Eine Bewertung von 1,0 kann auch ohne Punkte aus den Studienleistungen erreicht werden.	

Module ISDL-ISS2-M Optimization of IT-Reliant Processes *Optimierung IT-lastiger Geschäftsprozesse*		6 ECTS / 180 h
(since WS17/18) Person responsible for module: Prof. Dr. Tim Weitzel		
Contents: Content of the module covers theories, models and process models for optimization of IT-focused business processes. The module focuses primarily on the optimization of service provider processes. As a basis for this, the module provides theories and concepts of business process management and specializes in financial and HR processes (these processes are taken as examples for service provider processes). In the framework of the module the parallels to the industrialization of production processes will be discussed and the presented content will be deepened by case studies.		
Learning outcomes: Participants of the session should be able to identify and create optimization potential in IT-intensive business processes in service provider sector. In this context the module focuses on theories, concepts and methodologies of business process management. Here the module conveys analysis and design methods for the development of internal and external optimization, cooperation and sourcing potential.		
Remark: **The language of instruction in this course is German. However, all course materials (lecture slides and tutorial notes) as well as the exam are available in English.**		
prerequisites for the module: none		
Recommended prior knowledge: Keine		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Lecture: Optimierung IT-lastiger Geschäftsprozesse (ISS2) **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Tim Weitzel **Language:** German/English **Frequency:** every summer semester **Contents:** The aim of the course is to introduce knowledge and skills to provide optimization of IT-focused business processes. Hereby will be reviewed principles and tools of business process management and their implementation and application into financial and HR processes will be presented. Similarly, approaches to business process optimization through appropriate use of IT will be thematized in the lecture; typical primary and secondary service provider processes will be analyzed in terms of integration, efficiency and effectiveness; goals and methods for optimization will be discussed and process models for optimal process design and change management will be presented.	**2,00 Weekly Contact Hours**

Another focal point is a created economics theoretical dispute about the phenomenon, that companies outsource business processes or parts of them to external service providers. The four main areas of this lecture are:

Main focus is on **Business Process Management (BPM).** Design of

business processes is one of the core competencies of IS professionals.

Therefore, this lecture focuses on theories, models, tools, and methods of BPM, change management and business process standardization. These BPM concepts will be examined in more detail within the E-Finance, HER and Outsourcing sections. The objective is that students are able to design, standardize, manage and change business processes effectively and efficiently.

E-Finance: Financial processes can be generally considered as completely digitalizable and appear both as primary processes in the financial services industry and as secondary processes in all other firms. The lecture discusses how optimal IT usage can be attained in the financial service industry, which optimization potentials can be uncovered in the financial chain management of non-banks, and which re-structuring alternatives for the value chain by a “value chain crossing” are practical.

E-HR: The IT support of HR management processes is surprisingly

low. Therefore, the status quo and additional possibilities for this typical

secondary process will be introduced. Particularly, a (partial) automation

of the personnel selection process can be realized by employing

recommender systems. The lecture will discuss enablers and inhibitors of

IT usage in general and in HR in particular.

Sourcing: The questions of which services to be delivered, to where,

and by whom, are strategic questions in a BPM context. Advantages and

disadvantages, like economies of skill, scale, and scope, will be discussed and decision support models as well as “good practices” of business process outsourcing (BPO), along with problems and cultural barriers, will

be examined.

The scientific perspective is introduced and presented by the practice cases from partner companies.

Literature:

- Balaji et al. (2011), IT-led Business Process Reengineering: How Sloan Valve Redesigned it’s New Product Development Process, MIS Quarterly Executive, 10, 2, 81-92
- Borman, M. (2006): Identifying the Factors Motivating and Shaping Cosourcing in the Financial Services Sector, Journal of Information Technology Management, vol.17:3, pp. 11-25
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- Dibbern, J.; Goles, T.; Hirschheim, R.; Jayatilaka, B. (2004): Information Systems Outsourcing: A survey and Analysis of the Literature, The DATA BASE for Advances in Information Systems, 35 (4)
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- Eckhardt et al. 2012: Bewerbermanagementsysteme in deutschen Großunternehmen: Wertbeitrag von IKT für dienstleistungsproduzierende Leistungs- und Lenkungssysteme, Zeitschrift für Betriebswirtschaft (ZfB) (Journal of Business Economics)
- Gibson, C. (2003): IT-enabled business change: an approach to understanding and managing risk, MIS Quarterly Executive, 2 (2), 104-115
- Gilson et al. (2005): Creativity and Standardization: Complementary or Conflicting Drivers of Team Effectiveness? Academy of Management Journal, Vol. 48, No. 3, 521-531.
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- Hammer, M. 2007. “The Process Audit,” Harvard Business Review (85:4), pp. 111–123.
- Houy, C.; Fettke, P.; Loos, P.; van der Aalst, W. & Krogstie, J. (2011): Business Process Management in the Large, Business & Information Systems Engineering (3:6), 385-388.
- Lee, I. (2007): An Architecture for a Next-Generation Holistic E-Recruiting System", Communications of the ACM, 50(7)
- Münstermann & Weitzel (2008): What is process standardization?, Proceedings of the 2008 International Conference on Information Resources Management (Conf-IRM), Niagara Falls, Ontario, Canada
- Münstermann, Eckhardt, & Weitzel (2010): The performance impact of business process standardization. In: Business Process Management Journal (16:1), 29-56
- Münstermann, von Stetten, Eckhardt & Laumer (2010b): The Performance Impact of Business Process Standardization - HR Case Study Insights, Management Research Review (33:9), 924-939
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- Palmberg, Klara (2009): Exploring process management: are there any widespread models and definitions? In: The TQM Journal 21 (2), S. 203–215.Dumas, M., La Rosa, M., Mendling, J., and Reijers, H. 2013. Fundamentals of business process management, Berlin, New York: Springer
- Pfaff, D., Skiera, B., and Weitzel, T. (2004): Financial-Chain-Management: Ein generisches Modell zur Identifikation von Verbesserungspotenzialen, WIRTSCHAFTSINFORMATIK (46:2), 107-117

- Reijers at el. (2005), Best practices in business process redesign: an overview and qualitative evaluation of successful redesign heuristics. Omega 33(4), 283–306
- Shaw, D. R., Holland, C. P., Kawalek, P., Snowdon, B. and Warboys B. (2007): "Elements of a business process management system: theory and practice", Business Process Management Journal (13:1), pp. 91-107
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- Venkatesh, V. and H. Bala (2008), Technology Acceptance Model 3 and a Re-search Agenda on Interventions. Decision Sciences, 39 (2), p. 273-315.
- Wahrenburg, M.; König, W.; Beimborn, D.; Franke, J.; Gellrich, T.; Hackethal, A.; Holzhäuser, M.; Schwarze, F.; Weitzel, T. (2005): Kreditprozess-Management In: Books on Demand; Norderstedt
- Weitzel (2004): Economics of Standards in Information Networks, Springer Physica, New York.
- Weitzel, T., Eckhardt, A., von Westarp, F., von Stetten, A., Laumer, S., and Kraft, B. (2011): Recruiting 2011, Weka Verlag, Zürich, Schweiz.
- Weitzel, T., Eckhardt, A., Laumer, S. (2009): A Framework for Recruiting IT Talent: Lessons from Siemens, MIS Quarterly Executive (8:4), 123-137
- Weitzel, T., Martin, S., and König, W. (2003): Straight Through Processing auf XML-Basis im Wertpapiergeschäft, WIRTSCHAFTSINFORMATIK (45:4), 409-420
- Zairi, Mohamed (1997): Business process management: a boundary less approach to modern competitiveness. In: Business Process Management Journal 3 (1), S. 64–80.

2. Tutorial: Optimierung IT-lastiger Geschäftsprozesse (ISS2) **Mode of Delivery:** Practicals **Lecturers:** Scientific Staff Wirtschaftsinformatik, insb. Informationssysteme in Dienstleistungsbereichen **Language:** German/English **Frequency:** every summer semester	**2,00 Weekly Contact Hours**
Contents: The contents of the course will be deepened based on exercises and case studies. Communication of the content is focused on the exercises of the approach of "teaching cases". Hereby, the developed case studies will be developed and discussed with students. In addition to the work-up of the lecture content here will be emphasized: communication of soft skills, preparation for students' own application process to achieve and complete a successful management position. Corresponding workshops will be conducted jointly with partners from practice.	
Literature: siehe Vorlesung	

Examination Written examination / Duration of Examination: 90 minutes **Description:** In the exam the discussed content of lecture and tutorial will be tested. It is possible to achieve 90 points. During the semester there will be a possibility to process a semester assignment. The results will be assessed and by passed exam (usually achieving 45 points is required), points for the semester assignment will be taken into account by grading for the module. But achieving a 1.0 is possible without the credits for the semester assignment in any case.	

<table>
<tr><td colspan="2">Module ISDL-ISS3-M IT Business Value
IT-Wertschöpfung</td><td>6 ECTS / 180 h</td></tr>
<tr><td colspan="3">(since WS17/18)
Person responsible for module: Prof. Dr. Tim Weitzel</td></tr>
<tr><td colspan="3">Contents:
This module covers approaches for leveraging the human and technological IT resources and IT capabilities to create business value and generate a competitive advantage. Basic IT issues like the IT paradox, IT assets, IT strategy, IT architecture, IT governance and IT outsourcing management will be discussed. Using these concepts, practical guidelines for IT management will be illustrated with the help of several real world cases. Particularly in the services industry, IT represents a key production resource, and therefore, the focus of this module will be both on how to determine and how to increase the business value contribution of IT.

A main aspect for high IT effectiveness is the alignment of business and IT both at strategic (goals, plans, …) and at operational level (processes, services, …). Business/IT alignment is considered to be a key issue for academics and practitioners alike, dealing with the question of how the interplay between business and IT units can be put into effect? It will be shown that the superior application of IT is not primarily a technical challenge (choosing the right technology and implementing the right systems) rather than the consideration of an IT/IS portfolio which ensures effective usage and high productivity in the context of particular supported business processes. Based upon this, key techniques for IT management and the valuation of information systems will be introduced.</td></tr>
<tr><td colspan="3">Learning outcomes:
This module deals with the question to what extent and under which conditions IT contributes to organizational business value. Starting from this broad debate students will learn underlying theories, state-of-the-art concepts and concrete managerial guidelines on how to address the challenge of IT business value in practice. A key objective of the module is to provide the students with an in-depth understanding of managing both the technological and the human IT resources in order to use IT strategically and create measurable business value.</td></tr>
<tr><td colspan="3">Remark:
The language of instruction in this course is German. However, all course materials (lecture slides and tutorial notes) as well as the exam are available in English.</td></tr>
<tr><td colspan="3">prerequisites for the module:
none</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
keine</td><td>Admission requirements:
none</td></tr>
<tr><td>Frequency: every summer semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
1 Semester</td></tr>
</table>

<table>
<tr><td colspan="2">Module Units</td></tr>
<tr><td>1. Lecture: IT-Wertschöpfung (ISS3)
Mode of Delivery: Lectures
Lecturers: Prof. Dr. Tim Weitzel
Language: German/English
Frequency: every summer semester
Contents:</td><td>2,00 Weekly Contact Hours</td></tr>
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The lecture covers core issues within the areas IT business value and IT management.

- Theoretical lenses (e.g., Resource-based view, Dynamic Capabilities)
- IT Strategy
- IT Architecture
- IT Governance
- IT Business Alignment
- IT Outsourcing Management
- IT Valuation

Literature:

- Carr, N. (2003): IT Doesn't Matter, in: Harvard Business Review, Vol. 81, No. 5, With Letters to the Editor.
- Chan, Y.E., und Reich, B.H. (2007): IT alignment: what have we learned?, in: Journal of Information Technology, No. 22, pp. 297-315.
- Henderson, B.D. und Venkatraman, N. (1993): Strategic alignment: leveraging information technology for transforming organizations, in: IBM Systems Journal (32:1), pp. 4-16.
- Kohli, R., and Grover, V. (2008): Business Value of IT: An Essay on Expanding Research Directions to Keep up with the Times, in: Journal of the AIS, Vol. 9, No. 1, pp. 23-39.
- Melville, N., Kraemer, K., Gurbaxani, V. (2004): Review: Information Technology and Organizational Performance: An Integrative Model of IT Business Value, in: MIS Quarterly (28:2), pp. 283-322.
- Mitra et al. (2011): Measuring IT Performance and Communicating Value, in: MISQ Executive (10:1), pp. 47-59.
- Ross, J.W. (2003): Creating a Strategic IT Architecture Competency: Learning in Stages, in: MISQ Executive (2:1), pp. 31-43.
- Wade, M., und Hulland, J.S. (2004): Review : The Resource-Based View and Information Systems Research: Review, Extension, and Suggestions for Future Research, in: MIS Quarterly (28:1), pp. 107-142.

Weitere Literatur wird in der Veranstaltung bekannt gegeben.

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<tr><td>

2. Tutorial: IT-Wertschöpfung (ISS3)
Mode of Delivery: Practicals
Lecturers: Scientific Staff Wirtschaftsinformatik, insb. Informationssysteme in Dienstleistungsbereichen
Language: German/English
Frequency: every summer semester

Contents:
The content of the lectures will be discussed based on case studies.

Literature:
siehe Vorlesung

</td><td>**2,00 Weekly Contact Hours**</td></tr>
</table>

Examination Written examination / Duration of Examination: 90 minutes	

Description: The exam questions cover the content presented and discussed in lecture and tutorial. During the semester, students have the (optional) opportunity to do assignments and get extra points. However, these extra points will only be included into the evaluation if the exam itself is passed without the extra points (45 points or more).	

Module ISHANDS-Change-M Digital Change Management *Digital Change Management*	6 ECTS / 180 h
(since SS24) Person responsible for module: Prof. Dr. Christian Maier	

Contents:

Die digitale Transformation ist für Unternehmen essentiell, um langfristig konkurrenzfähig zu bleiben. Jedoch scheitern viele Transformationsprojekte an dem Widerstand der Belegschaft gegenüber Veränderungen.

Das Modul adressiert diesen Herausforderungen durch die Vermittlung verschiedener Methoden, Instrumente und Theorien. Es beleuchtet unterschiedliche Aspekte der Arbeitssystemtheorie, erforscht das Phänomen der Nutzerakzeptanz und -resistenz und diskutiert wirksame Interventionsstrategien. Zudem wird dargelegt, wie die Reaktionen der MitarbeiterInnen von ihren individuellen Erfahrungen, Persönlichkeitsmerkmalen und spezifischen Aufgabenbereichen beeinflusst werden. Dies hilft, um digitale Transformationsprojekte erfolgreich durchzuführen.

Ein innovatives Element des Kurses ist die Integration einer Planspielsimulation. Diese interaktive Simulation ermöglicht es den Studierenden, das theoretische Wissen praktisch anzuwenden, indem sie in die Rolle eines Change-Managers schlüpfen und den Prozess der digitalen Transformation aktiv begleiten. Ergänzt wird dies durch Einblicke in reale Fallstudien.

Der Kurs zielt darauf ab, Schlüsselfragen der digitalen Transformation zu klären, wie beispielsweise:

- Wie fördert die Arbeitssystemtheorie eine erfolgreiche digitale Transformation?
- Inwiefern ist das IT-Business Alignment für die digitale Transformation entscheidend und wer trägt hierfür die Verantwortung?
- Welche Methoden zur Transformation und Implementierung sind für das Management der digitalen Transformation effektiv?
- Warum entsteht Nutzerwiderstand gegenüber der digitalen Transformation?
- Wie differenzieren sich Nutzerakzeptanz und -widerstand?
- Welche Interventionen sind zur Steuerung der digitalen Transformation effektiv?

Learning outcomes:

Studierende erlangen ein tiefgreifendes Verständnis der komplexen Herausforderungen, die mit der digitalen Transformation verbunden sind. Dies schließt detaillierte Kenntnisse über verschiedene Implementierungsstrategien für digitale Technologien ein, sowie ein Bewusstsein für potenzielle Hindernisse, wie z.B. Widerstände seitens der Mitarbeitenden. Sie lernen spezifische Interventionstechniken, um solche Herausforderungen zu bewältigen. Darüber hinaus erwerben die Studierenden praktische Fähigkeiten in der Steuerung digitaler Veränderungsprojekte. Sie werden vertraut gemacht mit relevanten Managementmethoden und -werkzeugen, um digitale Transformationsprojekte nicht nur effektiv zu planen und zu gestalten, sondern auch erfolgreich umzusetzen. Ziel ist es, ihnen die Fähigkeiten zu vermitteln, digitale Veränderungen in Unternehmen strategisch und operativ zu führen.

Remark:

Alle Lehrmaterialien und Unterlagen für dieses Modul werden in englischer Sprache bereitgestellt. Die Vorlesungen sowie die Übungen werden jedoch in deutscher Sprache durchgeführt, um eine klare und verständliche Wissensvermittlung zu gewährleisten.

Der Gesamtarbeitsaufwand für dieses Modul setzt sich wie folgt zusammen:

- Aktive Teilnahme an Vorlesungen und Übungen: insgesamt etwa 45 Stunden.
- Selbstständige Vor- und Nachbereitung der Vorlesungsinhalte sowie Übungen: ungefähr 90 Stunden.
- Intensive Prüfungsvorbereitung: circa 45 Stunden.

Zusätzlich besteht die Möglichkeit, eine freiwillige Studienleistung zu erbringen, für die maximal 10 Bonuspunkte vergeben werden. Die Teilnahme an der Studienleistung vertieft das Verständnis des Lehrstoffs und trägt zur Verbesserung der Gesamtbewertung des Moduls bei.

Sowohl die Vorlesungen als auch die Übungen sind primär als Präsenzveranstaltungen konzipiert.

prerequisites for the module: none		
Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Digital Change Management **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Christian Maier **Language:** German **Frequency:** every summer semester	**2,00 Weekly Contact Hours**

Contents:

Die Vorlesung thematisiert beispielhaft die folgenden Schwerpunkte:

- Arbeitssystemtheorie
- IT-Business-Alignment
- Prozesse und Phasen des Change-Managements
- Change-Management-Theorien (z.B. Nutzerakzeptanz und -widerstände)
- Change-Management-Strategien und Methoden
- Management von IT-MitarbeiterInnen

Literature:

Jede Vorlesung baut auf aktueller, spezifischer Literatur auf, wie etwa:

- Alter, S. (2013). Work System Theory: Overview of Core Concepts, Extensions, and Challenges for the Future. Journal of the Association for Information Systems, 14 (2), 72-121.
- Bhattacherjee, A., Davis, C. J., Connolly, A. J., & Hikmet, N. (2018). User response to mandatory IT use: a coping theory perspective. European Journal of Information Systems, 27(4), 395–414.
- Kotter, J.P. (2010). Leading Change, Harvard Business Press.
- Laumer, S., Maier, C., Eckhardt, A. & Weitzel, T (2016). Work Routines as an Object of Resistance During Information Systems Implementations: Theoretical Foundation and Empirical Evidence. European Journal of Information Systems, 25, 317–343.
- Negoita, B., Rahrovani, Y., Lapointe, L., & Pinsonneault, A. (2022). Distributed IT championing: A process theory. Journal of Information Technology, 37(1), 2–30.

- Sykes, T. A. (2020). Enterprise System Implementation and Employee Job Outcomes: Understanding the Role of Formal and Informal Support Structures Using the Job Strain Model. MIS Quarterly, 44(4), 2055–2086.
- Wessel, L., Baiyere, A., Ologeanu-Taddei, R., Cha, J., & Blegind-Jensen, T. (2021). Unpacking the Difference Between Digital Transformation and IT-Enabled Organizational Transformation. Journal of the Association for Information Systems, 22(1), 102–129.

2. Digital Change Management **Mode of Delivery:** Practicals **Lecturers:** Scientific Staff Health and Society in the Digital Age **Language:** German **Frequency:** every summer semester **Contents:** Die Übung diskutiert die in der Vorlesung eingeführten Theorien und Methoden. Mittels Simulationen und Fallstudien werden diese angewandt und detailliert diskutiert. **Literature:** Siehe Vorlesung.	**2,00 Weekly Contact Hours**

Examination

Written examination / Duration of Examination: 90 minutes

Description:

In der Klausur werden die Lerninhalte, die während der Vorlesungen und Übungen behandelt wurden, geprüft. Insgesamt können in der Klausur bis zu 90 Punkte erreicht werden.

Studierende haben die Möglichkeit, durch die freiwillige Abgabe von semesterbegleitenden Studienleistungen bis zu 10 zusätzliche Punkte zu erlangen. Diese Bonuspunkte können zur Verbesserung der Gesamtnote verwendet werden, allerdings nur, wenn die Klausur bereits ohne diese Zusatzpunkte bestanden wurde.

Zu Beginn der Lehrveranstaltung werden die genauen Anforderungen und Modalitäten der Studienleistung bekannt gegeben, einschließlich der Art der Aufgabenstellung (zum Beispiel Einzel- oder Gruppenarbeit, Präsentationen oder Fallstudienanalyse). Es ist wichtig zu beachten, dass eine Bewertung von 1,0 auch ohne die zusätzlichen Punkte aus der Studienleistung erreicht werden kann.

Die Prüfung kann wahlweise in deutscher oder englischer Sprache absolviert werden.

Module ISHANDS-Health-M Digital Health *Digital Health*		6 ECTS / 180 h
Person responsible for module: Prof. Dr. Christian Maier		
Contents: Die Nutzung digitaler Technologien beeinflusst das Wohlbefinden von NutzerInnen auf unterschiedliche Arten. Es fördert die Gesundheit und das Wohlbefinden, indem digitale Technologien beispielsweise NutzerInnen dazu motivieren, regelmäßig aufzustehen oder Sport zu machen. Gleichzeitig geht die stetige Nutzung digitaler Technologien mit einem Stressempfinden einher, welches zu emotionaler Abgeschlagenheit oder Anzeichen von Burnout führen kann. Zusätzlich werden angrenzende Themen wie beispielsweise IT-Abhängigkeit oder Cybermobbing und verschiedene Trend-Themen wie beispielsweise Blockchain und KI mit Bezug zu Gesundheit thematisiert.		
Learning outcomes: Studierende lernen die Auswirkungen digitaler Technologie auf das Wohlbefinden kennen und können digitale Technologien dahingehend kritisch analysieren. Neben praxisnahen Erkenntnissen durch Fallstudien werden aktuelle Themenfelder der Wirtschaftsinformatik berücksichtigt.		
Remark: Alle Lehrmaterialien und Unterlagen für dieses Modul werden in englischer Sprache bereitgestellt. Die Vorlesungen sowie die Übungen werden jedoch in deutscher Sprache durchgeführt, um eine klare und verständliche Wissensvermittlung zu gewährleisten. Der Gesamtarbeitsaufwand für dieses Modul setzt sich wie folgt zusammen: • Aktive Teilnahme an Vorlesungen und Übungen: insgesamt etwa 45 Stunden. • Selbstständige Vor- und Nachbereitung der Vorlesungsinhalte sowie Übungen: ungefähr 90 Stunden. • Intensive Prüfungsvorbereitung: circa 45 Stunden. Zusätzlich besteht die Möglichkeit, eine freiwillige Studienleistung zu erbringen, für die maximal 10 Bonuspunkte vergeben werden. Die Teilnahme an der Studienleistung vertieft das Verständnis des Lehrstoffs und trägt zur Verbesserung der Gesamtbewertung des Moduls bei. Sowohl die Vorlesungen als auch die Übungen sind primär als Präsenzveranstaltungen konzipiert.		
prerequisites for the module: none		
Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Digital Health **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Christian Maier **Language:** German **Frequency:** every summer semester **Contents:** Die Vorlesung bietet einen Einblick in die verschiedenen Aspekte der Gesundheitsinformatik und deren transformative Rolle im Gesundheitswesen.	**2,00 Weekly Contact Hours**

Beginnend mit einer generellen Einführung beleuchtet die Vorlesung die Dualität digitaler Technologien. Dies beinhaltet beispielsweise Technologie-bedingten Stress, IT Abhängigkeit, Cybermobbing sowie positive Effekte von digitalen Technologien, nachdem diese von NutzerInnen in deren täglichen Routinen integriert werden. **Literature:** Jede Vorlesung baut auf aktueller, spezifischer Literatur auf, wie etwa: • Goh, J. M., Gao, G., & Agarwal, R. (2016). The Creation of Social Value: Can an Online Health Community Reduce Rural–Urban Health Disparities? MIS Quarterly, 40(1), 247–264. • Liang, H., & Xue, Y. (2022). Save face or save life: Physicians' dilemma in using clinical decision support systems. Information Systems Research 33(2), 737–758. • Maier, C., Laumer, S., Weinert, C. & Weitzel, T. (2015). The effects of technostress and switching-stress on discontinued use of social networking services: A study of Facebook use. Information Systems Journal, 25(3), 275–308. • Mattke, J., Maier, C., Hund, A. & Weitzel, T. (2019). How an Enterprise Blockchain Application in the U.S. Pharmaceutical Supply Chain is Saving Lives. MIS Quarterly Executive, 18(4), 246–261. • Meier, M., Maier, C., Thatcher, J. B., & Weitzel, T. (2023). Shocks and IS user behavior: A taxonomy and future research directions. Internet Research, 33(3), 853–889. • Park, E., Werder, K., Cao, L. & Ramesh, B. (2022). Why do Family Members Reject AI in Health Care? Competing Effects of Emotions. Journal of Management Information Systems, 39(3), 765–792. • Pfluegner, K., Maier, C., Thatcher, J. B., Mattke, J., & Weitzel, T. (2024). Deconstructing technostress: A configurational approach to explaining job burnout and job performance, MIS Quarterly	
2. Digital Health **Mode of Delivery:** Practicals **Lecturers:** Scientific Staff Health and Society in the Digital Age **Language:** German **Frequency:** every summer semester **Contents:** Die Übung vertieft die in der Vorlesung behandelten Theorien und Methoden der Gesundheitsinformatik. Mittels Fallstudien analysieren und diskutieren Studierende dabei die zuvor gelernten Theorien und Methoden. **Literature:** Siehe Vorlesung.	**2,00 Weekly Contact Hours**

Examination Written examination / Duration of Examination: 90 minutes **Description:**	

In der Klausur werden die Lerninhalte, die während der Vorlesungen und Übungen behandelt wurden, geprüft. Insgesamt können in der Klausur bis zu 90 Punkte erreicht werden. Studierende haben die Möglichkeit, durch die freiwillige Abgabe von semesterbegleitenden Studienleistungen bis zu 10 zusätzliche Punkte zu erlangen. Diese Bonuspunkte können zur Verbesserung der Gesamtnote verwendet werden, allerdings nur, wenn die Klausur bereits ohne diese Zusatzpunkte bestanden wurde. Zu Beginn der Lehrveranstaltung werden die genauen Anforderungen und Modalitäten der Studienleistung bekannt gegeben, einschließlich der Art der Aufgabenstellung (zum Beispiel Einzel- oder Gruppenarbeit, Präsentationen oder Fallstudienanalyse). Es ist wichtig zu beachten, dass eine Bewertung von 1,0 auch ohne die zusätzlichen Punkte aus der Studienleistung erreicht werden kann. Die Prüfung kann wahlweise in deutscher oder englischer Sprache absolviert werden.	

Module ISM-DSI-M Global Collaboration and Digital Social Innovation *Global Collaboration and Digital Social Innovation*	6 ECTS / 180 h
(since WS23/24) Person responsible for module: Prof. Dr. Daniel Beimborn	

Contents:

In 2015, the United Nations agreed on a common approach to peace and prosperity for people and the planet. At its core are the 17 Sustainable Development Goals (SDGs), which represent an urgent call to action by all countries as part of a global partnership. In particular, it is about developing strategies to improve health and education, reduce inequality, and boost economic growth – all while combating climate change and working to protect our oceans and forests. In this context, innovation on a global scale is an essential component. In particular, social innovation, defined as "a novel solution to a social problem that is more effective, efficient, sustainable, or just than existing solutions and for which the value created accrues primarily to society as a whole rather than private individuals" (Phills et al. 2008, p. 36), can have a positive impact not only on the economic conditions of individuals, but also on the environment (e.g., waste management) and politics (e.g., transparency in governance and political participation).

Digital technologies can support these endeavors by allowing relevant stakeholders to interact across borders without hierarchical order or spatial restrictions. For instance, Ahuja and Chan (2020) show how entrepreneurs used a digital platform to orchestrate multiple to organize waste collection in India. Hence, digital social innovation aims at leveraging digital tools to address societal challenges.

Objective of this project is to ideate, conceptualize and implement a digital solution to a social or environmental problem. To understand the wider implications of such sustainability problems and solutions, it is important to learn about other contexts, such as other countries with different business and legal regimes, or other cultures and mindsets. In this project, students will gain such a competence by collaborating in mixed teams with students from the Welingkar Institute of Management, Development and Research (WeSchool – a highly ranked business university with campuses in Mumbai and Bangalore).

At the end of the semester, the German students will travel to India and finalize their project, present their results, and get also first-hand insights into the Indian culture and IT industry.

Learning outcomes:

After completing the course, students will understand the challenges, goals, and approaches of digital social innovation projects in different regions, such as in Germany and India. They will be able to design digital solutions to social problems, understand intercultural differences, and consider these when developing digital solutions. The course also prepares students to work in intercultural teams and promotes critical skills such as presenting work results and working on projects in a goal-oriented manner. During the visit to India, students will also get insights into the Indian culture, economy, and digital industry.

prerequisites for the module:

none

Recommended prior knowledge:	**Admission requirements:**
ISM-EidWI-B: Introduction into Information Systems ISM-FIISM-B: Fundamentals of International IS Management DSG-EiAPS-B: Introduction to Algorithms, Programming and Software	none

Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** Semester

Module Units	
Global Collaboration and Digital Social Innovation **Language:** English/Deutsch / English on demand **Frequency:** every winter semester	**0,00 Weekly Contact Hours**

Learning outcome:

After completing the course, students will understand the challenges, goals, and approaches of digital social innovation projects in different regions, such as in Germany and India. They will be able to design digital solutions to social problems, understand intercultural differences, and consider these when developing digital solutions. The course also prepares students to work in intercultural teams and promotes critical skills such as presenting work results and working on projects in a goal-oriented manner. During the visit to India, students will also get insights into the Indian culture, economy, and digital industry.

Contents:

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Examination Coursework Assignment with presentation, Global Collaboration and Digital Social Innovation	

Module ISM-IOM-M International Outsourcing Management *International Outsourcing Management*	6 ECTS / 180 h
(since WS20/21) Person responsible for module: Prof. Dr. Daniel Beimborn	

Contents:

- Grundlagen des Outsourcings: Definitionen, grundlegende Konzepte und Arten von Outsourcing; Geschichte, Trends; Märkte und Wachstum; Überblick über die wissenschaftliche Forschung im Outsourcing-Kontext
- Outsourcing-Gründe und grundlegende Theorien: Ökonomische und strategische Gründe für Outsourcing; Theorien zu Kosten- und strategischen Vorteilen, Kernkompetenzen usw.
- Outsourcing-Risiken: Ökonomische und strategische Risiken durch Outsourcing
- Outsourcing-Entscheidungen: Analyse der Nutzenpotenziale und Risiken durch Outsourcing; Modelle zur Bewertung der Vorteilhaftigkeit von Outsourcing; Prozess und Bewertungskriterien zur Auswahl von Dienstleistern
- Outsourcing-Verträge: Gestaltung und Verhandlung von Outsourcing-Verträgen und Service-Level-Agreements; Verhandlung mit einem Dienstleister; ausgewählte regulatorische Rahmenbedingungen
- Organisatorische Vorbereitungen im eigenen Unternehmen („Outsourcing Readiness"); Vorbereitung und Durchführung des Transitionsvorgangs
- Outsourcing-Governance: Aufbau einer Outsourcing-Governance zur Steuerung der Dienstleisterbeziehung; Kontrolle, Change-Management und Beziehungsmanagement; Management des Wissensaustausches und Fördern von Innovationen
- Besonderheiten beim Cloud Computing: Grundlegende Konzepte und Arten von Cloud Computing als besonderer Form von Outsourcing; Spezifische Vorteile, Herausforderungen und Risiken von Cloud Computing; spezifische Aspekte bei Cloud-basierten Sourcing-Entscheidungen sowie bei einer Cloud-Computing-Governance
- Offshore- und Nearshore-Outsourcing: Besonderheiten hinsichtlich Risiken, Kosten und Chancen; Bedeutung von und Umgang mit kulturellen Unterschieden; Globale IT-Delivery-Modelle
- Ökonomische und gesellschaftliche Auswirkungen von Outsourcing und Offshoring: Gesellschaftliche Reaktionen und Veränderungen; Implikationen für nationale Arbeitsmärkte und globale IT-Märkte

Learning outcomes:

Die Teilnehmer können Chancen und Risiken von IT-Outsourcing in Firmen identifizieren, Outsourcing-Projekte planen (Outsourcing-Strategie, Business Case, Auswahl unterschiedlicher Sourcing-Modi und Vendorenmodelle) und implementieren (Vertragsmanagement, Outsourcing-Governance, Beziehungsmanagement, Wissenstransfer). Damit sind Sie in der Lage,

- die grundlegenden Argumente für das Treffen von IT-Outsourcing-Entscheidungen zu identifizieren und zu evaluieren(Wann macht Outsourcing Sinn?),
- IT-Outsourcing-Optionen zu identifizieren und zu bewerten (Welche Form von Outsourcing ist sinnvoll?),
- IT-Outsourcing-Projekte zu planen und zu managen (Wie kann ein erfolgreicher Transfer zum Dienstleister gewährleistet werden?),
- eine Outsourcing-Governance zu implementieren (Wir wird gesteuert? Wer hat welche Verantwortlichkeiten inne?),
- IT-Outsourcing-Beziehungen zu gestalten und zu managen (Vertragsmanagement, Kontrolle, Beziehungsmanagement, Wissenstransfer) sowie

Nearshore- und Offshore-IT-Outsourcing-Optionen zu identifizieren und zu bewerten.
Remark: Der Arbeitsaufwand für dieses Modul gliedert sich ungefähr wie folgt: • Teilnahme an Vorlesung und Übung: insgesamt 45 Stunden • Vor- und Nachbereitung der Vorlesung und Übung (inkl. Recherche und Studium zusätzlicher Quellen): 90 Stunden • Prüfungsvorbereitung inkl. Prüfung: 45 Stunden (basierend auf dem bereits im obigen Sinne erarbeiteten Stoff) Für das erfolgreiche Absolvieren des Moduls ist die regelmäßige Teilnahme an den Lehrveranstaltungen und die Vorbereitung von Fallstudien/Readings empfohlen.
prerequisites for the module: none

Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
International Outsourcing Management **Mode of Delivery:** **Lecturers:** Prof. Dr. Daniel Beimborn **Language:** German **Frequency:** every winter semester **Contents:** Outsourcing, der Fremdbezug von Leistungen von einem Dienstleister, ist eine wichtige Handlungsoption für IT-Manager. In diesem Modul werden Grundlagen, Vor- und Nachteile des Outsourcing sowie Entscheidungsmodelle, Vorgehensweisen, „Good Practices" („warum outsourcen, was outsourcen, wie outsourcen?"), aber auch Probleme und kulturelle Hürden im Bereich IT-Outsourcing und -Offshoring vermittelt, diskutiert und angewendet. Neben klassischem Outsourcing werden auch Cloud-basierte IT-Delivery-Modelle und die entsprechenden Management-besonderheiten betrachtet. Auf Basis von ausführlichen Vorlesungsunterlagen und mittels Diskussion von Fallstudien werden die Management-Anforderungen für die Gestaltung eines erfolgreichen Outsourcing-Arrangements umfassend vermittelt. Anhand von Übungsaufgaben werden die Inhalte zusätzlich ausführlich vertieft. Eine Vorbereitung der Lektüre für jede Einheit ist zwingend erforderlich. Die Universität Bamberg ist der einzige deutsche Academic Alliance Partner der International Association of Outsourcing Professionals (IAOP), die sich die globale Qualitätssteigerung und Standardisierung von Outsourcing-Management- Kompetenzen zum Ziel gesetzt hat. Entsprechend werden maßgeblich auch internationale (englischsprachige) Lehrmaterialien der IAOP verwendet. **Literature:** Beimborn, D. 2008. Cooperative Sourcing - Simulation Studies and Empirical Data on Outsourcing Coalitions in the Banking Industry. Wiesbaden: Gabler.	**4,00 Weekly Contact Hours**

Carmel, E., and Tjia, P. 2005. Offshoring Information Technology - Sourcing and Outsourcing to a Global Workforce. Cambridge: Cambridge University Press. IAOP. 2014. Outsourcing Professional Body of Knowledge. Zaltbommel: VanHaren Publishing. Lacity, M.C., Khan, S.A., and Willcocks, L.P. 2009. "A Review of the IT Outsourcing Literature: Insights for Practice," Journal of Strategic Information Systems (18:3), pp 130-146. Oshri, I., Kotlarksy, J., and Willcocks, L. 2015. The Handbook of Global Outsourcing and Offshoring. London, New York: Palgrave. Weitere Literatur zu den einzelnen Themen wird in den jeweiligen Vorlesungen bekannt gegeben.	

Examination Written examination / Duration of Examination: 90 minutes **Description:** Durch die freiwillige Abgabe von semesterbegleitenden Studienleistungen können Punkte zur Notenverbesserung gesammelt werden, die auf die Klausur anrechenbar sind, sofern die Klausur auch ohne Punkte aus Studienleistungen bestanden ist. Zu Beginn der Lehrveranstaltung wird bekannt gegeben, ob Studienleistungen angeboten werden. Falls Studienleistungen angeboten werden, wird zu diesem Zeitpunkt auch die Anzahl, die Art, der Umfang und die Bearbeitungsdauer der Studienleistungen sowie die Anzahl an erreichbaren Punkten pro Studienleistung und in der Modulprüfung bekannt gegeben. Eine Bewertung von 1,0 kann auch ohne Punkte aus den Studienleistungen erreicht werden.	

<table>
<tr><td colspan="2">Module ISPL-DIGB-B Digital Business
Digital Business</td><td>6 ECTS / 180 h</td></tr>
<tr><td colspan="3">(since WS24/25)
Person responsible for module: Prof. Dr. Thomas Kude</td></tr>
<tr><td colspan="3">Contents:
Digital business is omnipresent in today's world, fundamentally transforming how organizations operate and compete. This module provides a comprehensive introduction to the essential apsects of modern digital enterprises. Students will gain foundational knowledge on different logics of digital value creation and key concepts related to digital business, including digital business models, digital commerce, as well as digital products, services, and processes.

Students will explore technological and managerial aspects of digital business at various levels--industry, oragnizational, team, and individual. The course includes practical examples as well as methods and tools for creating and managing digital businesses.</td></tr>
<tr><td colspan="3">Learning outcomes:
After having completing this module, participants will be able to:
• Understand the technological foundations and principles of digital business
• Design and manage digital products and services effectively
• Analyze digital business processes across organizational levels, industries, and domains
• Implement strategies for digital transformation in different business contexts</td></tr>
<tr><td colspan="3">Remark:
The required workload of 180h is subdivided into:
• 56h for participation in lecture and exercise
• 124h for preparation and post-processing of sessions as well as exam preparation</td></tr>
<tr><td colspan="3">prerequisites for the module:
none</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
none
Module Introduction into Information Systems (ISM-EidWI-B) - recommended</td><td>Admission requirements:
none</td></tr>
<tr><td>Frequency: every winter semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
1 Semester</td></tr>
</table>

<table>
<tr><td colspan="2">Module Units</td></tr>
<tr><td>1. Digital Business
Mode of Delivery: Lectures
Lecturers: Prof. Dr. Thomas Kude
Language: English
Frequency: every winter semester

Contents:
In the lecture, we discuss digital business from various perspectives, including but not limited to the underlying logic of digital value creation and associated technologies, different archetypical digital business models and organizational contexts, digital products, services, and processes.</td><td>2,00 Weekly Contact Hours</td></tr>
</table>

Literature: The specific literature that we will use in the course will be communicated or distributed in class or through the learning platform (VC). Students may have to purchase cases.	
2. Digital Business **Mode of Delivery:** Practicals **Lecturers:** Prof. Dr. Thomas Kude **Language:** English **Frequency:** every winter semester **Contents:** In the exercise, we deepen and practice the content of the lecture through examples, case discussions, and presentations, some of which will be done in groups. **Literature:** See lecture	**2,00 Weekly Contact Hours**

Examination Written examination / Duration of Examination: 90 minutes **Description:** The exam questions will incude the content from the lecture, exercises, and assignments. Students can reach 90 points in the exam. Students may obtain additional points to improve their grade through the voluntary participation in group or individual assignments. These points can be included in the exam points if a student would pass the exam without the additional points. The respective assignment, the available time, and the points that can be reached in each assignment will be communicated if and once such voluntary assignments are offered. The best grade (1,0) can be reached without participating in the voluntary assignments.	

<table>
<tr><td colspan="2">Module ISPL-DPIS-M Digital Platforms in Industries and Society
Digital Platforms in Industries and Society</td><td>6 ECTS / 180 h</td></tr>
<tr><td colspan="3">(since WS23/24)
Person responsible for module: Prof. Dr. Thomas Kude</td></tr>
<tr><td colspan="3">Contents:
Digital platforms have become instrumental in shaping industries and societies, touching aspects from entertainment to healthcare, and from personal well-being to urban development. This course delves into the multifaceted impact of digital platforms on industries and society, exploring both their potential benefits and the challenges they introduce. Beginning with an introduction to digital platforms and the platform economy, the course progresses to examine the implications of these platforms on individuals, collectives, and various industry sectors. Through a blend of theoretical discussions, practical case studies, and hands-on activities, students will gain a comprehensive understanding of the role digital platforms play in contemporary society.</td></tr>
<tr><td colspan="3">Learning outcomes:
After the course, participants will be able to...
Understand the foundational concepts of digital platforms
Analyze the multi-faceted impacts of platforms on individuals and society
Examine the adaptation and transformation of various industries due to digital platforms
Engage critically with real-world impact of digital platforms from various perspectives
Develop strategies and opportunities to harness the potential of digital platforms in diverse sectors effectively</td></tr>
<tr><td colspan="3">Remark:
The required workload of 180h is approximately subdivided into:
56h for participation in lecture and exercise
124h for preparation and post-processing of sessions as well as exam preparation</td></tr>
<tr><td colspan="3">prerequisites for the module:
none</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
Good command of the English Language.</td><td>Admission requirements:
none</td></tr>
<tr><td>Frequency: every winter semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
1 Semester</td></tr>
</table>

<table>
<tr><td colspan="2">Module Units</td></tr>
<tr><td>1. Digital Platforms in Industries and Society
Mode of Delivery: Lectures
Lecturers: Prof. Dr. Thomas Kude
Language: English
Frequency: every winter semester<hr>Contents:
In the lecture, we discuss the role of digital platforms in industries and society from multiple perspectives, such as education, healthcare, urban development, or the changing role of trust.</td><td>2,00 Weekly Contact Hours</td></tr>
</table>

Literature: The specific literature that we will use in the course will be communicated or distributed in class or through the learning platform (VC). Students may have to purchase cases.	
2. Digital Platforms in Industries and Society **Mode of Delivery:** Practicals **Lecturers:** Prof. Dr. Thomas Kude **Language:** English **Frequency:** every winter semester **Contents:** In the exercise, we deepen and practice the content of the lecture through examples, case discussions, and presentations, some of which will be done in groups. **Literature:** See lecture	**2,00 Weekly Contact Hours**

Examination Written examination / Duration of Examination: 90 minutes **Description:** The exam questions will include the content from the lecture, exercises, and assignments. Students can reach 90 points in the exam. Students may obtain additional points to improve their grade through the voluntary participation in group or individual assignments. These points can be included in the exam points if a student would pass the exam without the additional points. The respective assignments, the available time, and the points that can be reached in each assignment will be communicated if and once such voluntary assignments are offered. The best grade (1,0) can be reached without participating in the voluntary assignments.	

Module ISPL-FIISM-B Fundamentals of International IS Management *Fundamentals of International IS Management*		6 ECTS / 180 h
(since SS24) Person responsible for module: Prof. Dr. Thomas Kude		
Contents: This module equips IISM students with the basics of their IISM curriculum and serves as an introductory course. Building on the basics of information systems (IS)--such as the content of ISM-EidWI-B, SNA-WIM-B or similar courses--we develop a deeper understanding of IS management, international management, and idiosyncrasies of IS management in an international context. Accordingly, the course is structured along these three areas.		
Learning outcomes: After having completed this course, students will have an understanding of IS management in an international context. They will be able to handle basic IS management tasks in an international environment and they will be sensitive to challenges caused by international and intercultural settings as well as by virtual collaboration.		
Remark: The workload of 180 academic hours is allocated as follows: • 56h for participating in class • 80h for preparing classes (i.e., retrieving and studying literature and cases, completing small assignments) and reviewing course material after class • 44h for self-managed studies and preparing for and taking the final exam		
prerequisites for the module: none		
Recommended prior knowledge: ISM-EidWI-B (or any equivalent "Introduction to IS" course) is required. SNA-WIM-B is recommended, but not necessary (students can catch up the relevant parts by reading some extra literature).		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:** from 4.	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Fundamentals of International IS Management **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Thomas Kude **Language:** English **Frequency:** every summer semester **Contents:** In this course, students will gain a deeper understanding of IS management tasks and issues with a particular focus on international contexts and environments. Therefore, the course will first give an overview about important IS management fields, then give an introduction to (general) international management,	**2,00 Weekly Contact Hours**

and finally combine both foundational parts by discussing particularities of managing information systems in an international context (i.e., the core of IISM). Accordingly, the course will consist of three parts:

Part 1: IS management

- IS strategy
- IS governance
- IS sourcing

Part 2: International management

- Theoretical and conceptual foundations of international management
- Organization of international firms
- Foreign market entry strategies
- Intercultural management and virtual teams

Part 3: International IS management

- Managing global IT organizations and people
- Managing global IT/software development projects and system roll-outs
- Managing offshore IT outsourcing
- Global issues of IS management--ethics and sustainability

Literature:
Will be announced in class.

2. Fundamentals of International IS Management — **2,00 Weekly Contact Hours**

Mode of Delivery: Practicals
Lecturers: Prof. Dr. Thomas Kude
Language: English
Frequency: every summer semester

Contents:
The content of the course will be reviewed by assignment tasks and discussion of case studies.

Literature:
see lecture

Examination
Written examination / Duration of Examination: 90 minutes
Description:
In the exam, the content covered in the module (lecture, exercise, readings) is examined. The maximum number of points in the exam is 90.

It is possible to earn bonus points for the exam during the lecture term. Earned bonus points will be credited to the results if the exam has been passed successfully. Bonus points can be earned by completing a voluntary, written coursework in which students independently have to work on transfer tasks related to the lecture course. It will be announced at the beginning of the course whether bonus points are offered. If bonus points are offered, the number, type, scope, and duration of the assignments as well as the number of attainable bonus

points will be announced at this time. A final grade of 1.0 can be achieved without bonus points from the coursework.	

Module ISPL-MASI-B Supplier relationships and mergers & acquisitions in the software industry *Supplier relationships and mergers & acquisitions in the software industry*		3 ECTS / 90 h
(since WS24/25) Person responsible for module: Prof. Dr. Thomas Kude further responsible : Popp, Michael, Karl Dr.		
Contents: This course equips students with the basics of key activities in the software industry: software supply chains and mergers & acquisitions. The content ranges from supply side value chains, like inbound OEM, open-source components or APIs, to mergers and acquisitions, including players, deal types, processes, opportunities, and risks, with a detailed examination of goals, valuations, and transactions in the recent software M&A market.		
Learning outcomes: After successful completion of this course, participants will be able to: 1. Analyze supply chains of software vendors. 2. Define and evaluate supply relationships in software supply chains by discussing risks and opportunities of such relationships. 3. Identify players and roles in mergers and acquisitions processes. 4. Define phases and tasks of M&A processes. 5. Understand and discuss valuations of software companies. 6. Analyze opportunities and risks of M&A projects.		
prerequisites for the module: none		
Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Supplier relationships and mergers & acquisitions in the software industry **Language:** English **Frequency:** every winter semester **Contents:** This course equips students with the basics of key activities in the software industry: software supply chains and mergers & acquisitions. The content ranges from supply side value chains, like inbound OEM, open-source components or APIs, to mergers and acquisitions, including players, deal types, processes, opportunities, and risks, with a detailed examination of goals, valuations, and transactions in the recent software M&A market. **Literature:** Will be announced in class.	**2,00 Weekly Contact Hours**

Examination Written examination / Duration of Examination: 90 minutes **Description:** The exam questions will incude the content from the lecture, exercises, and assignments.	

Module ISPL-MDP-M Managing Digital Platforms *Managing Digital Platforms*		6 ECTS / 180 h
(since WS23/24) Person responsible for module: Prof. Dr. Thomas Kude		
Contents: Digital platforms are ubiquitous in industries and in society and both researchers and practitioners have recognized their disruptive potential. Large technology companies, such as Apple, Alibaba, Amazon, or SAP, rely on a platform business model and the emergence of the thriving platform economy has contributed to the meteoric rise of some platform owners to top the lists of the most valuable companies in the world. The central actors in the context of digital platforms include the platform owner that provides the platform itself along with interfaces and other resources, outside third-party actors that provide complementary products and services, as well as the users of the platform. For example, in the context of mobile app ecosystems, complementors can leverage platform functionality of iOS or Android to create apps and use Apple's App Store or the Google Play Store to offer them to iPhone or Android users. In this course, we develop a comprehensive understanding of the management of digital platforms through an in-depth exploration of the roles and mechanisms of digital platforms and the surrounding ecosystems. After laying the foundations of digital platform management, we will dive into advanced questions of platform design and management, e.g., related to platform launch, to governing third-party contributions, or to key success factors for the various actors in digital platform ecosystems. The course relies on both theoretical insights and practical cases across industries and companies.		
Learning outcomes: After the course, participants will be able to... • Recognize the growing importance of digital platforms • Analyze the underlying mechanisms and the roles of different actors in digital platform ecosystems • Make decisions regarding the governance of different types of platforms • Develop strategies and business models for complementor organizations that benefit from and depend on digital platforms		
Remark: The required workload of 180h is approximately subdivided into: • 56h for participation in lecture and exercise • 124h for preparation and post-processing of sessions as well as exam preparation		
prerequisites for the module: none		
Recommended prior knowledge: Good command of the English language		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Managing Digital Platforms **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Thomas Kude **Language:** English	**2,00 Weekly Contact Hours**

Frequency: every summer semester **Contents:** In the lecture, we will work on central topics of managing platform ecosystems, including, but not limited to: • Foundations of digital platforms • Launching and monetizing digital platforms • Digital platform governance • The role of complementors in digital platforms **Literature:** The specific literature that we will use in the course will be communicated or distributed in class or through the learning platform (VC). Students may have to purchase cases.	
2. Managing Digital Platforms **Mode of Delivery:** Practicals **Lecturers:** Prof. Dr. Thomas Kude **Language:** English **Frequency:** every summer semester **Contents:** In the exercise, we will deepen and practice the content of the lecture through examples and case discussions, some of which will be done in groups. **Literature:** See lecture	**2,00 Weekly Contact Hours**

Examination Written examination / Duration of Examination: 90 minutes **Description:** The exam questions will include the content from lecture, exercises, and assignments. Students can reach 90 points in the exam. Students may obtain additional points to improve their grade though the voluntary participation in group or individual assignments These points can be included in the exam points if a student would pass the exam without the additional points. The respective assignments, the available time, and the points that can be reached in each assignment will be communicated if and once such voluntary assignments are offered. The best grade (1,0) can be reached without participating in the voluntary assignments.	

Module Inf-DM-B Discrete Modeling *Diskrete Modellierung*		9 ECTS / 270 h
(since WS24/25) Person responsible for module: Prof. Dr. Isolde Adler		
Contents: Modellieren ist eine grundlegende Arbeitstechnik in vielen Bereichen der Informatik und darüber hinaus. Modelle dienen der exakten Beschreibung von Szenarien und sind damit die Voraussetzung zum Lösen von Problemen mittels Methoden der Informatik. Dabei ist es wichtig, die Modelle passend zur Problemstellung zu wählen. Hier bietet die diskrete Mathematik ein vielfältiges Handwerkszeug. Für das nachhaltige, verlässliche Modellieren sowie für das Lösen von Problemen ist es wichtig, das exakte Argumentieren zu erlernen. Deshalb ist das Einüben der Sprache der Mathematik ein zentrales Thema in diesem Modul. Sie bietet die Sicherheit, sich auf die Modelle und Lösungen verlassen zu können. In diesem Modul werden Aussagen- und Prädikatenlogik, Mengen, Relationen und Funktionen, Graphen, Bäume, und Methoden der Kombinatorik, formale Sprachen und endliche Automaten eingeführt und anhand von Modellierungsbeispielen besprochen. Zudem werden mathematische Beweistechniken eingeführt und eingeübt.		
Learning outcomes: Vertrautheit mit unterschiedlichen Modellierungsmethoden Sicherheit im mathematisch exakten Argumentieren Vertrautheit mit grundlegenden Definitionen und Eigenschaften aus dem Bereich der diskreten Mathematik und mit deren Rolle in der Informatik Sicherheit in der Entwicklung von Strategien zur Problemlösung Analytische Fähigkeiten		
prerequisites for the module: Keine		
Recommended prior knowledge: Interesse an formalen Methoden. Dies ist eine grundlegende Veranstaltung, die für die ersten Studiensemester empfohlen wird.		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Diskrete Modellierung **Mode of Delivery:** Lectures and Practicals **Lecturers:** Prof. Dr. Isolde Adler **Language:** English **Frequency:** every winter semester **Contents:**	**6,00 Weekly Contact Hours**

In der Vorlesung werden die Themen motiviert und eingeführt, im Detail erklärt sowie Techniken und Methoden vorgestellt. Es werden Beispiele, Beweise, typische Fragestellungen und Anwendungen in der Informatik besprochen.	

Examination Written examination	

Module KogSys-KI-B Introduction to Artificial Intelligence *Einführung in die Künstliche Intelligenz*	6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Ute Schmid	

Contents:

The module provides an introduction to the basic concepts and methods of Artificial Intelligence. Central topics are search and problem solving, games and constraints, knowledge representation and logic, reasoning, and planning. Selected aspects of advanced topics from the areas of uncertain knowledge, machine learning, language and communication, image analysis and robotics are covered. In addition to the theoretical basics, the implementation of AI algorithms in Scheme and Prolog is taught. The lecture also addresses the history of AI, interdisciplinary references, in particular to philosophy and psychology, as well as ethical questions of AI.

List of topics:

• Problem solving and search
• Search algorithms for games
• Approaches to knowledge representation
• Propositional and first order logic
• Inference in first order logic
• Non-classical logics
• Planning
• Machine Learning
• Language Processing
• Object and scene recognition

Learning outcomes:

• Be able to define and explain basic concepts and problems of AI
• Be able to apply simple AI algorithms to specific – including new – problems
• Be able to model problems formally, in particular using logic
• Master the basics of AI programming techniques (especially functional and logical programming)

Remark:

• Be able to define and explain basic concepts and problems of AI
• Be able to apply simple AI algorithms to specific – including new – problems
• Be able to model problems formally, in particular using logic
• Master the basics of AI programming techniques (especially functional and logical programming)

prerequisites for the module:

(except for interdisciplinary module Cognitive Artificial Intelligence)
• GdI-MfI-1 (Propositional and Predicate Logic)
• DSG-EiAPS-B (Introduction to Algorithms, Programming and Software)

Recommended prior knowledge:	**Admission requirements:**
Knowledge in the following areas, associated modules in brackets: • Algorithms and Data Structures (AI-AuD-B)	None

• Introduction to Functional Programming (GdI-IFP-B) • Fundamentals of Theoretical Informatics (GdI-GTI-B) • Linear Algebra (xAI-MML-M, KTR-MfI-2-B)		
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Introduction to Artificial Intelligence **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Ute Schmid **Language:** German/English **Frequency:** every summer semester **Learning outcome:** see module description **Contents:** Presentation and discussion of the contents (see module description), in particular theoretical and conceptual aspects. **Literature:** Stuart Russel and Peter Norvig (2010, 3rd edition). Artificial Intelligence, a modern approach. Prentice Hall	**2,00 Weekly Contact Hours**
Examination / Duration of Examination: 105 minutes **Description:** The duration of the exam includes a reading time of 15 minutes in order to be able to select the tasks to be completed within the scope of the options available. 90 points can be achieved in the written examination. The exam is passed if at least 40 percent are achieved. Voluntary assignments are issued during the semester. By voluntarily completing the assignments, students can collect points to improve their grade, which can be credited towards the exam, provided that the exam is passed even without points from the optional assignments. This will be announced at the beginning of the course: • Type and number of assignments • Scope (number of achievable points) of the assignments • Duration for completing the assignments A grade of 1.0 can also be achieved without points from the assignments. Permitted aids: Handwritten and printed materials, calculator without full alphanumeric keyboard and graphic display. The tasks in the exam are provided in German and English.	

Module Units	
Introduction to Artificial Intelligence **Mode of Delivery:** Practicals **Lecturers:** Bettina Finzel **Language:** German/English **Frequency:** every summer semester	**2,00 Weekly Contact Hours**
Learning outcome: see module description	
Contents: Practical consolidation of the contents of the lecture: • Repetition and consolidation of theoretical concepts presented in the lecture • Simulation of algorithms for search, logical inference, planning and machine learning (manual and programmatic) • Tasks for knowledge modeling and for modeling logical worlds • Calculation of heuristics • Probability calculation • Elaboration of example applications in which artificial intelligence can be used • Presentation and discussion of task solutions	

<table>
<tr><td colspan="2">Module KogSys-Proj-B Bachelor Project Cognitive Systems
Bachelor-Projekt Kognitive Systeme</td><td>6 ECTS / 180 h</td></tr>
<tr><td colspan="3">(since WS24/25)
Person responsible for module: Prof. Dr. Ute Schmid</td></tr>
<tr><td colspan="3">Contents:
Building on the knowledge and skills acquired in the lectures and exercises in the field of cognitive systems, students work on a scientific question in small groups. In doing so, students acquire skills in scientific work in the research field of cognitive systems as well as skills in teamwork.</td></tr>
<tr><td colspan="3">Learning outcomes:
Students can, with support, work on a narrowly defined topic:
• Place concrete research questions in the state of research
• Design and clearly formulate research questions and research objectives
• Describe, compare and evaluate research methods in the field of cognitive systems
• Name and explain basic principles of assessment and evaluation of research results and apply them to specific research questions
• Depending on the topic, implement a problem solution or concept or carry out and evaluate an empirical study according to instructions or present algorithms and procedures precisely and formally
• Work on a scientific question in a team
• Present research results orally and in writing</td></tr>
<tr><td colspan="3">Remark:
Time required:
• 20h personal meetings with the lecturer
• 30h Preparation of literature (incl. algorithms, systems)
• 80h Concretization and implementation of the project task
• 10h Preparation of the final presentation
• 40h Writing the report</td></tr>
<tr><td colspan="3">prerequisites for the module:
At least one of the following:
• KogSys-KI-B (Introduction to Artificial Intelligence)
• KogSys-ML-B (Introduction to Machine Learning)</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
Knowledge according to the following modules:
Module Intelligent Agents (KogSys-IA-B)
Module Foundations of Cognitive Computer Science (KogSys-KogInf-Psy)</td><td>Admission requirements:
none</td></tr>
<tr><td>Frequency: every summer semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
1 Semester</td></tr>
</table>

Module Units	
Project Cognitive Systems **Mode of Delivery:** **Lecturers:** Prof. Dr. Ute Schmid, Johannes Langer, Bettina Finzel **Language:** German/English **Frequency:** every semester **Learning outcome:** See module description **Contents:** In the Bachelor project, changing topics from the field of cognitive systems, which are related to the group's current research work, are worked on in small groups (2-3 students). Scientific work in the field of cognitive systems is practiced as an example: Processing the relevant literature to anchor the topic according to the state of research, realization in the form of the implementation of an algorithm, the evaluation of algorithms or systems based on selected problems or the empirical investigation of a cognitive question. Presentation of the results in the form of a scientific publication, presentation and defense of the work in a colloquium. The language of instruction will be announced in the first lecture **Literature:** Will be provided at the start of the semester	**4,00 Weekly Contact Hours**
Examination Coursework Assignment and Colloquium / Duration of Examination: 20 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regelmäßige Teilnahme an der Lehrveranstaltung **Description:** Realisation of the project task, documentation in the form of a scientific publication as a term paper. The examination language will be announced in the first course.	

Module KogSys-Sem-B Bachelor Seminar Cognitive Systems *Bachelorseminar Kognitive Systeme*		3 ECTS / 90 h
(since WS24/25) Person responsible for module: Prof. Dr. Ute Schmid		
Contents: Building on the knowledge and skills acquired in the lectures and exercises in the field of Artificial Intelligence, the independent development and presentation of a topic area on the basis of scientific literature is practiced in the seminar. The seminar topics are from the field of artificial intelligence, for example • Explainable AI • Human-in-the-Loop Learning • AI and Education • Neuro-symbolic AI • Representation Learning • Ultra Strong Machine Learning • Generative AI		
Learning outcomes: • Familiarization with a specific question from the field of artificial intelligence based on scientific literature with a focus on a specific algorithm or a specific method based on a given text • Search for scientific literature and evaluation of quality and relevance • Oral presentation of a scientific paper • Writing a research paper according to a given format along a research question in English • Discussion of scientific papers in the seminar		
Remark: Time required: • 22,5h presence • 2.5h personal meetings with the lecturer • 30h Preparation of the literature • 10h Preparation of the presentation • 25h Preparation of the written paper		
prerequisites for the module: At least one of the following: • KogSys-KI-B (Introduction to Artificial Intelligence) • KogSys-ML-B (Introduction to Machine Learning)		
Recommended prior knowledge: none Module Introduction to Artificial Intelligence (AI-KI-B) - recommended		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Bachelorseminar Kognitive Systeme **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Ute Schmid, Johannes Langer, Bettina Finzel **Language:** German/English **Frequency:** every winter semester **Learning outcome:** See module description **Contents:** See module description **Literature:** Will be announced at the beginning of the seminar	**2,00 Weekly Contact Hours**
Examination Coursework Assignment with presentation / Duration of Examination: 30 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regelmäßige Teilnahme an der Lehrveranstaltung **Description:** Written paper on the topic dealt with in the seminar. The examination language will be announced in the first lecture.	

Module MII-ProjCR-B Bachelor Project Cognitive Robotics *Bachelorprojekt Kognitive Robotik*		6 ECTS / 180 h
(since SS24) Person responsible for module: Prof. Dr. Markus Rickert		
Contents: In diesem Projekt werden die Grundlagen im Bereich der kognitiven Robotik anhand einer praktischen Umsetzung an einem Robotermanipulator vermittelt. Dazu gehören das Verständnis der direkten und inversen Kinematik, die Erkennung von Objekten mittels Bildverarbeitung und die Steuerung von Robotermanipulatoren und Endeffektoren durch Middlewares wie z.B. ROS. In Kombination mit kognitiven Fähigkeiten, wie dem Erstellen eines Weltmodells mit Hilfe von Wissensrepräsentation und logischem Denken, besteht die Aufgabe der Studierenden darin, allgemeine Probleme im Bereich der Robotik zu lösen. Die letzte Aufgabe besteht aus einem Wettbewerb zwischen je zwei Gruppen, die an dem Kurs teilnehmen.		
Learning outcomes: Studierende erwerben Kenntnisse über reale Roboteranwendungen und lernen, ein integriertes System für eine kognitive Roboterzellen zu entwickeln.		
prerequisites for the module: none		
Recommended prior knowledge: Gute Kenntnisse in objektorientierten Programmiersprachen (C++, Python). Kenntnisse in Robotik, kognitiven Systemen, Bildverarbeitung sowie ROS (Robot Operating System) können von Vorteil sein. Empfohlene Module: Einführung in die Robotik (MII-ROB-B)		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:** from 3.	**Minimal Duration of the Module:** 1 Semester

Module Units	
Bachelorprojekt Kognitive Robotik **Mode of Delivery:** Seminar **Language:** German/English **Frequency:** every summer semester	**4,00 Weekly Contact Hours**

Examination Coursework Assignment and Colloquium / Duration of Examination: 20 minutes Duration of Coursework: 4 months	

Module MII-ProjCR-M Master Project Cognitive Robotics *Masterprojekt Kognitive Robotik*	6 ECTS / 180 h
(since SS24) Person responsible for module: Prof. Dr. Markus Rickert	

Contents:
In diesem Projekt werden die Grundlagen im Bereich der kognitiven Robotik anhand einer praktischen Umsetzung an einem Robotermanipulator vermittelt. Dazu gehören das Verständnis der direkten und inversen Kinematik, die Erkennung von Objekten mittels Bildverarbeitung und die Steuerung von Robotermanipulatoren und Endeffektoren durch Middlewares wie z.B. ROS. In Kombination mit kognitiven Fähigkeiten, wie dem Erstellen eines Weltmodells mit Hilfe von Wissensrepräsentation und logischem Denken, besteht die Aufgabe der Studierenden darin, allgemeine Probleme im Bereich der Robotik zu lösen. Die letzte Aufgabe besteht aus einem Wettbewerb zwischen je zwei Gruppen, die an dem Kurs teilnehmen.

Learning outcomes:
Studierende erwerben Kenntnisse über reale Roboteranwendungen und lernen, ein integriertes System für eine kognitive Roboterzellen zu entwickeln.

prerequisites for the module:
none

Recommended prior knowledge: Gute Kenntnisse in objektorientierten Programmiersprachen (C++, Python). Kenntnisse in Robotik, kognitiven Systemen, Bildverarbeitung sowie ROS (Robot Operating System) können von Vorteil sein. Empfohlene Module: Einführung in die Robotik (MII-ROB-B)		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Masterprojekt Kognitive Robotik **Mode of Delivery:** Seminar **Language:** German/English **Frequency:** every summer semester	**4,00 Weekly Contact Hours**

Examination	
Coursework Assignment and Colloquium / Duration of Examination: 20 minutes Duration of Coursework: 4 months	

Module MII-SemHRI-B Bachelor Seminar Human-Robot Interaction *Bachelorseminar Mensch-Roboter-Interaktion*		3 ECTS / 90 h
(since WS23/24) Person responsible for module: Prof. Dr. Markus Rickert		
Contents: Eine große Herausforderung bei der Interaktion zwischen Mensch und Roboter liegt in der gemeinsamen Bearbeitung von komplexen Aufgaben. Ein Robotersystem muss in der Lage sein, die aktuelle Umgebung wahrzunehmen, Intentionen und Ziele vorauszusehen, mittels verschiedener Modalitäten mit seinem Gegenüber zu kommunizieren und physisch mit der Umgebung und dem Menschen zu interagieren. Das Seminar gibt einen allgemeinen Überblick über die Herausforderungen bei dieser Form der Interaktion zwischen Mensch und Roboter.		
Learning outcomes: Studierende lernen, sich ein ausgewähltes Thema anhand aktueller Fachliteratur zu erarbeiten und mündlich wie auch schriftlich zu präsentieren.		
prerequisites for the module: none		
Recommended prior knowledge: Keine Vorkenntnisse erforderlich; Kenntnisse in Robotik, kognitiven Systemen, Bild- oder Sprachverarbeitung können von Vorteil sein.		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** Semester

Module Units	
Bachelorseminar Mensch-Roboter-Interaktion **Mode of Delivery:** Seminar **Language:** German/English **Frequency:** every winter semester	**2,00 Weekly Contact Hours**

Examination Internship report / Duration of Examination: 20 minutes Duration of Coursework: 4 months	

Module MII-SemHRI-M Master Seminar Human-Robot Interaction *Masterseminar Mensch-Roboter-Interaktion*		3 ECTS / 90 h
(since WS23/24) Person responsible for module: Prof. Dr. Markus Rickert		
Contents: Eine große Herausforderung bei der Interaktion zwischen Mensch und Roboter liegt in der gemeinsamen Bearbeitung von komplexen Aufgaben. Ein Robotersystem muss in der Lage sein, die aktuelle Umgebung wahrzunehmen, Intentionen und Ziele vorauszusehen, mittels verschiedener Modalitäten mit seinem Gegenüber zu kommunizieren und physisch mit der Umgebung und dem Menschen zu interagieren. Das Seminar gibt einen allgemeinen Überblick über die Herausforderungen bei dieser Form der Interaktion zwischen Mensch und Roboter.		
Learning outcomes: Studierende lernen, sich ein ausgewähltes Thema anhand aktueller Fachliteratur zu erarbeiten und mündlich wie auch schriftlich zu präsentieren.		
prerequisites for the module: none		
Recommended prior knowledge: Keine Vorkenntnisse erforderlich; Kenntnisse in Robotik, kognitiven Systemen, Bild- oder Sprachverarbeitung können von Vorteil sein.		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** Semester

Module Units	
Masterseminar Mensch-Roboter-Interaktion **Mode of Delivery:** Seminar **Language:** German/English **Frequency:** every winter semester	**2,00 Weekly Contact Hours**

Examination Internship report / Duration of Examination: 20 minutes Duration of Coursework: 4 months	

Module MOBI-ADM-M Advanced Data Management *Advanced Data Management*		6 ECTS / 180 h 45 h Präsenzzeit 135 h Selbststudium
(since SS21) Person responsible for module: Prof. Dr. Daniela Nicklas		
Contents: With the rapid growth of the internet and more and more observable processes, many data sets became so large that they cannot be processed with traditional database methods any more. This modul covers advanced data management and integration techniques (also known under the term “big data”) that are useful when dealing with very large data sets.		
Learning outcomes: The students will understand the challenges of big data, and will be able to apply some of the new techniques to deal with it.		
Remark: The main language of instruction in this course is English. However, the lectures and/or tutorials may be delivered in German if all participating students are fluent in German. The written reports/seminar essay and the presentation may be delivered in English or in German.		
prerequisites for the module: none		
Recommended prior knowledge: Foundations of relational databases, relational algebra and SQL; e.g. from Modul SEDA-DMS-B: Data management systems		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Lectures Advanced Data Management **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Daniela Nicklas **Language:** English **Frequency:** every summer semester **Contents:** The lecture will cover various algorithms for clustering, association rule mining, or page ranking and their scalable processing using map and reduce methods, data integration, data cleansing and entity recognition. The exercises will be built upon the Hadoop framework. The language of the course will be announced in the first lecture. **Literature:** L. Wiese, Advanced Data Management, For SQL, NoSQL, Cloud and Distributed Databases. Berlin, Boston: De Gruyter, 2015	**2,00 Weekly Contact Hours**
2. Practicals Advanced Data Management **Mode of Delivery:** Practicals **Lecturers:** Prof. Dr. Daniela Nicklas	**2,00 Weekly Contact Hours**

Language: English
Frequency: every summer semester

Contents:
see Lectures

The language of the course will be announced in the first lecture.

Examination
Written examination / Duration of Examination: 75 minutes
Description:
Central written exam. The examination language is English.

The exam questions will be in English. The questions can be answered in English or German. The content that is relevant for the exam consists of the content presented in the lecture and in the practical assignments.

The exam consists of 7 tasks of which only 6 will be graded. The exam time includes a reading time of 15 minutes to select the tasks to be completed within the scope of the choices.

Participants who submit solutions for practical assignments can achieve bonus points. Details regarding the number of assignments, the number of bonus points per assignment, the conversion factor from bonus points to exam points (e.g., 10:1) and the type of assignments will be announced in the first practical assignment session.

If the points achieved in the exam are sufficient to pass the exam on its own (generally, this is the case when at least 50% of the points have been obtained), the converted bonus points will be added to the points achieved in the exam.

The grade 1.0 can be achieved without the bonus points.

<table>
<tr><td colspan="2">Module MOBI-DSC-M Data Streams and Complex Event Processing
Data Streams and Complex Event Processing</td><td>6 ECTS / 180 h
45 h Präsenzzeit
135 h Selbststudium</td></tr>
<tr><td colspan="3">(since WS20/21)
Person responsible for module: Prof. Dr. Daniela Nicklas</td></tr>
<tr><td colspan="3">Contents:
The management of data streams and foundations of event processing: Applications, systems, query languages, continuous query processing, and security in distributed data stream management systems.

The modul covers the following topics: Architectures of data stream management systems; Query languages; Data stream processing; Complex event processing; Security in data stream management systems; Application of data stream management systems</td></tr>
<tr><td colspan="3">Learning outcomes:
Understand the challenges of data stream management and complex event processing

Recognize and link basic building blocks of data stream management tasks in different frameworks and systems

Develop and program queries on data streams and event streams in different query languages to process data streams and detect event patterns

Understand basic implementation techniques for data stream operators

Understand the main security challenges and solutions in data stream management systems</td></tr>
<tr><td colspan="3">prerequisites for the module:
none</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
Foundations of relational databases, relational algebra and SQL; e.g. from Modul MOBI-DBS-B: Database Systems</td><td>Admission requirements:
none</td></tr>
<tr><td>Frequency: every winter semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
1 Semester</td></tr>
</table>

<table>
<tr><td colspan="2">Module Units</td></tr>
<tr><td>Data Streams and Complex Event Processing
Mode of Delivery: Lectures
Lecturers: Prof. Dr. Daniela Nicklas
Language: English
Frequency: every winter semester
<hr>Learning outcome:
Understand the challenges of data stream management and complex event processing

Recognize and link basic building blocks of data stream management tasks in different frameworks and systems

Develop and program queries on data streams and event streams in different query languages to process data streams and detect event patterns

Understand basic implementation techniques for data stream operators</td><td>2,00 Weekly Contact Hours</td></tr>
</table>

Understand the main security challenges and solutions in data stream management systems **Contents:** The management of data streams and foundations of event processing: Applications, systems, query languages, continuous query processing, and security in distributed data stream management systems. The modul covers the following topics: Architectures of data stream management systems; Query languages; Data stream processing; Complex event processing; Security in data stream management systems; Application of data stream management systems	
Examination Oral examination / Duration of Examination: 15 minutes **Description:** oral or written exam (will be announced in class at the beginning of the semester). The examination language is English.	

Module Units	
Data Streams and Complex Event Processing **Mode of Delivery:** Practicals **Language:** English **Frequency:** every winter semester **Contents:** see lecture	**2,00 Weekly Contact Hours**

Examination Written examination / Duration of Examination: 60 minutes **Description:** oral or written exam (will be announced in class at the beginning of the semester). The examination language is English.	

Module MOBI-PRS-M Master Project Mobile Software Systems (SoSySc) *Master Project Mobile Software Systems (SoSySc)*	9 ECTS / 270 h

(since SS24)
Person responsible for module: Prof. Dr. Daniela Nicklas

Contents:
Applications of in mobile software systems, which are taken from current research activities in mobile, context-aware systems and data stream management, are carried out in part individually and in part in small teams of students, from conception, via theoretical and/or practical realization, to evaluation. In particular, the project concerns the development of sound concepts pertaining to the task to be addressed under the given project constraints. This requires studying the current research literature and relevant approaches on the project's topic.

An example of a project task would be the conceptual development, the prototypic implementation, and the case-study-driven evaluation of a small sensor-based, mobile system, which would require knowledge from the modul MOBI-DSC-M Data streams and event processing.

The tasks in the project will be tailored to Master level.

Learning outcomes:
Students will deepen their knowledge regarding the conceptual problems that arise when carrying out theoretical and/or practical research and software projects, and regarding approaches to possible solutions. Since this will be done by means of the intensive conduct of a research topic in Mobile Software Systems, students will gain important experience in carrying out research-oriented projects, from project planning, to the abstract and concrete design, to the realization, to the documentation of results in a scientific project report.

Remark:
The main language of instruction in this course is English. However, the lectures and/or tutorials may be delivered in German if all participating students are fluent in German.

The written reports/seminar essay and the presentation may be delivered in English or in German.

prerequisites for the module:
none

Recommended prior knowledge:	Admission requirements:
Basic programming skills (Java or Python); scientific writing skills, e.g., obtained from the course SSS-SRW-M or from a scientific Bachelor thesis; basic knowledge in Mobile Computing as offered, e.g., by the course MOBI-MSS-B. Dependent on the topic of the specific project, additional knowledge as discussed in the courses MOBI-DSC-M or MOBI-ADM-M can be required.	none

Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Master Project Mobile Software Systems (SoSySc) **Mode of Delivery:** **Lecturers:** Prof. Dr. Daniela Nicklas	**6,00 Weekly Contact Hours**

Language: English/German **Frequency:** every summer semester	
Contents: Conduct of the project, accompanied by regular meetings between students and lecturer. The language of the course will be announced in the first lecture.	
Examination Coursework Assignment and Colloquium **prerequisites for module examination:** Regelmäßige Teilnahme an der Lehrveranstaltung **Description:** Als Prüfungsleistung ist eine Hausarbeit sowie ein Kolloquium zu erbringen. Die Bearbeitungsfrist der Hausarbeit und die Prüfungsdauer des Kolloquiums werden zu Beginn einer jeden Lehrveranstaltung von der Projektleiterin bzw. dem Projektleiter bekannt gegeben. Production of a written report on the software project carried out (Assignment/ Hausarbeit). Discussion of this project report and of the developed artefacts in the context of the wider project topic (Colloquium/Kolloquium). The term of the project report and of the colloquium will be announced at the beginning of each course by the project leader.	

Module MOBI-Proj-B Bachelor Project Mobile Software Systems *Bachelor Project Mobile Software Systems*	6 ECTS / 180 h

(since SS24)
Person responsible for module: Prof. Dr. Daniela Nicklas

Contents:
Applications of in mobile software systems, which are taken from current research activities in mobile, context-aware systems and data stream management, are carried out in part individually and in part in small teams of students, from conception, via theoretical and/or practical realization, to evaluation. In particular, the project concerns the development of sound concepts pertaining to the task to be addressed under the given project constraints. This requires studying the current research literature and relevant approaches on the project's topic.

An example of a project task would be the conceptual development, the prototypic implementation, and the case-study-driven evaluation of a small sensor-based, mobile system, which would require knowledge from the modul MOBI-DSC Data streams and event processing.

The tasks in the project will be tailored to Bachelor level.

Learning outcomes:
Studierende sollen ein vertieftes Verständnis der bei der Durchführung von Softwaresystem-Projekten auftretenden konzeptionellen und praktischen Probleme wie auch von erfolgsversprechenden Lösungsansätzen zu diesen Problemen erhalten. Da dies anhand der intensiven Bearbeitung eines Themas aus dem Forschungsbereich von mobilen Softwaresystemen in Kleingruppen – oder ggf. auch einzeln – geschieht, gewinnen die Studierenden wichtige Erfahrungen in der Durchführung kleinerer, forschungsorientierter Projekte von der Grobkonzeption über die Detailplanung bis hin zur Umsetzung und Dokumentation der Ergebnisse in wissenschaftlich ausgerichteten Arbeitsberichten und in der Präsentation dieser Ergebnisse.

Remark:
The main language of instruction in this course is English. However, the lectures and/or tutorials may be delivered in German if all participating students are fluent in German.

The written reports/seminar essay and the presentation may be delivered in English or in German.

prerequisites for the module:
none

Recommended prior knowledge: Programmierkenntnisse sowie grundlegende methodische Kenntnisse zur Planung und Durchführung von Softwareprojekten, z. B. erworben im Modul "Software Engineering Lab" (SWT-SWL-B), und zum wissenschaftlichen Arbeiten, z. B. erworben im Modul "Wissenschaftliches Arbeiten in der Informatik" (IAIWAI-B).	**Admission requirements:** none

Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units

Bachelor project Mobile Software Systems **Mode of Delivery:**	**4,00 Weekly Contact Hours**

Lecturers: Prof. Dr. Daniela Nicklas **Language:** English/German **Frequency:** every semester **Contents:** The language of the course will be announced in the first lecture.	

Examination Coursework Assignment and Colloquium **prerequisites for module examination:** regelmäßige Teilnahme an der Lehrveranstaltung **Description:** The language of the exam will be announced in the first lecture.	

<table>
<tr><td colspan="2">Module MOBI-Proj-M Master Project Mobile Software Systems
Master Project Mobile Software Systems</td><td>6 ECTS / 180 h</td></tr>
<tr><td colspan="3">(since SS24)
Person responsible for module: Prof. Dr. Daniela Nicklas</td></tr>
<tr><td colspan="3">Contents:
Applications of in mobile software systems, which are taken from current research activities in mobile, context-aware systems and data stream management, are carried out in part individually and in part in small teams of students, from conception, via theoretical and/or practical realization, to evaluation. In particular, the project concerns the development of sound concepts pertaining to the task to be addressed under the given project constraints. This requires studying the current research literature and relevant approaches on the project's topic.

An example of a project task would be the conceptual development, the prototypic implementation, and the case-study-driven evaluation of a small sensor-based, mobile system, which would require knowledge from the modul MOBI-DSC Data streams and event processing.

The tasks in the project will be tailored to Master level.</td></tr>
<tr><td colspan="3">Learning outcomes:
Students will deepen their knowledge regarding the conceptual problems that arise when carrying out theoretical and/or practical research on software projects, and regarding approaches to possible solutions. Since this will be done by means of the intensive conduct of a research topic in Mobile Software Systems, students will gain important experience in carrying out research-oriented projects, from project planning, to the abstract and concrete design, to the realization, to the documentation of results in a scientific project report.</td></tr>
<tr><td colspan="3">Remark:
The main language of instruction in this course is English. However, the lectures and/or tutorials may be delivered in German if all participating students are fluent in German.

The written reports/seminar essay and the presentation may be delivered in English or in German.</td></tr>
<tr><td colspan="3">prerequisites for the module:
none</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
Foundations of relational databases, relational algebra and SQL; e.g. from Modul SEDA-DMS-B: Data management systems</td><td>Admission requirements:
none</td></tr>
<tr><td>Frequency: every winter semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
1 Semester</td></tr>
</table>

<table>
<tr><td colspan="2">Module Units</td></tr>
<tr><td>Master project Mobile Software Systems
Mode of Delivery:
Lecturers: Prof. Dr. Daniela Nicklas
Language: English/German
Frequency: every winter semester
Contents:
The language of the course will be announced in the first lecture.</td><td>4,00 Weekly Contact Hours</td></tr>
</table>

Examination Coursework Assignment and Colloquium **prerequisites for module examination:** Regelmäßige Teilnahme an der Lehrveranstaltung **Description:** The language of the exam will be announced in the first lecture.	

Module MOBI-SEM-B Bachelor-Seminar Mobile Software Systems *Bachelor-Seminar Mobile Software Systems*		3 ECTS / 90 h
(since WS19/20) Person responsible for module: Prof. Dr. Daniela Nicklas		
Contents: Immer mehr Anwendungen beruhen auf Sensoren, mit denen kontinuierlich auch detaillierte Nutzerdaten erfasst werden können. Die Themen dieses Seminars beschäftigen sich mit verschiedenen Verfahren, wie die Datensicherheit und Privatsphäre in solchen Anwendungen gewahrt werden kann.		
Learning outcomes: gaining professional competence regarding the critical and systematic analysis of scientific literature; learning techniques to structure complex facts in the field of software systems science in systematic manner; evaluation of competing approaches; learning techniques to present scientific topics in professional manner and to write scientific papers.		
Remark: The module covers independent study and presentation of a topic on the chosen subject area, using scientific methods. Details on the topic and literature will be will be announced by the lecturer offering this module a the beginning of the seminar. The seminar thesis and the presentation may be delivered in English or in German		
prerequisites for the module: none		
Recommended prior knowledge: Scientific research and writing, e.g. from the module "IAIWAI-B Wissenschaftliches Arbeiten" or "SSS-SRW-M Scientific Research on Writing for Master´s Students".		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Mobile Software Systems **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Daniela Nicklas **Language:** English **Frequency:** every winter semester **Contents:** The language of the course will be announced in the first lecture.	**2,00 Weekly Contact Hours**
Examination Coursework Assignment with presentation **Description:** The language of the exam will be announced in the first lecture.	

Module MOBI-SEM-M Master-Seminar Mobile Software Systems *Master-Seminar Mobile Software Systems*		3 ECTS / 90 h
(since WS17/18) Person responsible for module: Prof. Dr. Daniela Nicklas		
Contents: Sensors continuously supply data that often cannot be understood by machines in its raw form. The topics in this seminar deal with different processes of how to obtain better information from continuous (sensor) data streams.		
Learning outcomes: gaining professional competence regarding the critical and systematic analysis of scientific literature; learning techniques to structure complex facts in the field of software systems science in systematic manner; evaluation of competing approaches; learning techniques to present scientific topics in professional manner and to write scientific papers.		
Remark: The module covers independent study and presentation of a topic on the chosen subject area, using scientific methods. Details on the topic and literature will be will be announced by the lecturer offering this module a the beginning of the seminar. The seminar thesis and the presentation may be delivered in English or in German		
prerequisites for the module: none		
Recommended prior knowledge: Scientific research and writing, e.g. from the module "IAIWAI-B Wissenschaftliches Arbeiten" or "SSS-SRW-M Scientific Research on Writing for Master´s Students".		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Mobile Software Systems **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Daniela Nicklas **Language:** English **Frequency:** every winter semester **Contents:** The language of the course will be announced in the first course.	**2,00 Weekly Contact Hours**
Examination Coursework Assignment with presentation **Description:** The language of the exam will be announced in the first course.	

Module NLProc-ANLP-M Applied Natural Language Processing *Angewandte maschinelle Sprachverarbeitung*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Roman Klinger		
Contents: The module of Applied Natural Language Processing can be filled with various specialized courses from the Chair of Fundamentals of Natural Language Processing. This includes specialized lectures and seminars. The module is worth 6 credit points. Therefore two classes of 3 credit points can be combined or one 6 credit point class can be taken.		
Learning outcomes: The student learns about recent research topics in natural language processing, learns to familiarize themselves with state of the art methods and challenges, and learns to build on knowledge from machine learning, deep learning, structured learning, computational linguistics, and semantics.		
prerequisites for the module: none		
Recommended prior knowledge: • Information Retrieval and Text Mining (recommended) • Algorithmisches Sprachverstehen (recommended) • Deep Learning (very helpful)		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Emotion Analysis **Mode of Delivery:** Lectures and Practicals **Lecturers:** Prof. Dr. Roman Klinger **Language:** English **Frequency:** every summer semester **Learning outcome:** This class discusses the fundaments of emotion theories in psychology and how they can be used for computational modeling, such that computers can interpret emotions in text. The content is: • Emotion theories • Appraisal theories • Lexicons and applications of emotion analysis • Machine and deep learning for emotion analysis • Event interpretation • Structured analyses of emotions	**2,00 Weekly Contact Hours** **3.0 ECTS**
2. Emotion Analysis Project **Mode of Delivery:** **Lecturers:** Prof. Dr. Roman Klinger	**2,00 Weekly Contact Hours** **3.0 ECTS**

Language: English/German **Frequency:** every semester	
Learning outcome: The student learns to apply emotion analysis methods to new tasks and domains.	
Contents: This course extends the Emotion Analysis lecture of 3 credit points to a course of 6 credit points can only be taken together with the lecture. This is not a standard "project" course but an extension of the emotion analysis lecture which can not be taken without the lecture.	
Examination Internship report **Description:** This module can be filled with either a specialized lecture (3 ECTS) together with a short additional project (another 3 ECTS) or with a seminar; or two seminars (each 3 ECTS). Depending on the class type, the exam will take on a different modality. Typically, for seminars it is a presentation and a written paper ("Referat + Hausarbeit") while for the emotion analysis course it is Hausarbeit + Colloquium. Other future classes might decide on a different modality. Students will be informed in the first week of a lecture about that.	

<table>
<tr><td colspan="2">Module NLProc-ILT-M Impact of Language Technology
Impact of Language Technology</td><td>6 ECTS / 180 h</td></tr>
<tr><td colspan="3">(since WS24/25)
Person responsible for module: Prof. Dr. Roman Klinger</td></tr>
<tr><td colspan="3">Contents:
Topics include
Value Sensitive Design,
Bias and Discrimination,
Intersectionality,
Emergent Bias in Translation Technologies,
Content Moderation and Toxicity Detection,
Documentation and Transparency,
Science Communictation,
Privacy</td></tr>
<tr><td colspan="3">Learning outcomes:
This course aims to deepen our understanding of the ethical issues associated with deploying NLP technology. We will explore how to identify those likely to be affected by the technology (both direct and indirect stakeholders), assess the risks involved, and design systems that better align with stakeholder values.
Through discussions of readings from the expanding body of research on fairness, accountability, transparency, and ethics in NLP and related fields, as well as value-sensitive design, we will address the following questions:
- What specific harms can arise from the use of NLP systems?
- How can we fix, prevent, or mitigate these harms?
- What responsibilities do we have as NLP researchers and developers in this context?</td></tr>
<tr><td colspan="3">prerequisites for the module:
none</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
Required is an understanding of machine learning techniques and mechanisms, knowledge of NLP is a plus but not required</td><td>Admission requirements:
none</td></tr>
<tr><td>Frequency: every winter semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
1 Semester</td></tr>
</table>

<table>
<tr><td colspan="2">Module Units</td></tr>
<tr><td>Societal Impact of Language Technology
Mode of Delivery: Lectures and Practicals
Language: English
Frequency: every winter semester
Learning outcome:
This course aims to deepen our understanding of the ethical issues associated with deploying NLP technology. We will explore how to identify those likely to be affected by the technology (both direct and indirect stakeholders), assess the risks involved, and design systems that better align with stakeholder values.</td><td>4,00 Weekly Contact Hours</td></tr>
</table>

Through discussions of readings from the expanding body of research on fairness, accountability, transparency, and ethics in NLP and related fields, as well as value-sensitive design, we will address the following questions: - What specific harms can arise from the use of NLP systems? - How can we fix, prevent, or mitigate these harms? - What responsibilities do we have as NLP researchers and developers in this context? **Contents:** Topics include • Value Sensitive Design, • Bias and Discrimination, • Intersectionality, • Emergent Bias in Translation Technologies, • Content Moderation and Toxicity Detection, • Documentation and Transparency, • Science Communictation, • Privacy **Literature:** A variety of different sources from current research are used. Among them: Birhane, A. 2021. The Impossibility of Automating Ambiguity. Artificial Life, 27(1):44-61. Lewis, J.E. et al, 2020. Indigenous Protocol and Artificial Intelligence Friedman, B. (1996). Value-sensitive design. ACM Interactions, 3 (6), 17-23. Leidner, J. L., & Plachouras, V. (2017). Ethical by design: Ethics best practices for natural language processing. In Proceedings of the first ACL workshop on ethics in natural language processing (pp. 30-40). Valencia, Spain: Association for Computational Linguistics	
Examination Written examination / Duration of Examination: 60 minutes	

<table>
<tr><td colspan="2">Module NLProc-PGM4NLP-M Probabilistic Graphical Models for Natural Language Processing
Probabilistic Graphical Models for Natural Language Processing</td><td>6 ECTS / 180 h</td></tr>
<tr><td colspan="3">(since WS24/25)
Person responsible for module: Prof. Dr. Roman Klinger</td></tr>
<tr><td colspan="3">Contents:
The course will provide an introduction to probabilistic graphical models, through the lens of natural language processing. Some topics covered will include
• Directed graphical models / Bayesian networks
• Undirected graphical models / Markov random fields
• Conditional random fields
• Causal modeling
• Structured prediction with graphical models
• Inference and sampling from graphical models
• Training methods for graphical models
• Neural graphical models.</td></tr>
<tr><td colspan="3">Learning outcomes:
The goal of this course is to provide an introduction to probabilistic graphical models, and their use in natural language processing. We will start with formalisms for directed and undirected graphical models, before branching out into more specific applications for specific task domains in natural language processing. Students should leave with a basic understanding of how probabilistic graphical models work, and how they can be applied to tasks within natural language processing.</td></tr>
<tr><td colspan="3">prerequisites for the module:
none</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
Students should have prior experience with probability theory, statistics, or machine learning. Prior experience of natural language processing might be helpful, but is not required.</td><td>Admission requirements:
none</td></tr>
<tr><td>Frequency: every winter semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
1 Semester</td></tr>
</table>

<table>
<tr><td colspan="2">Module Units</td></tr>
<tr><td>Probabilistic Graphical Models for Natural Language Processing
Mode of Delivery: Lectures and Practicals
Language: English
Frequency: every winter semester
Learning outcome:
The goal of this course is to provide an introduction to probabilistic graphical models, and their use in natural language processing. We will start with formalisms for directed and undirected graphical models, before branching out into more specific applications for specific task domains in natural language processing. Students should leave with a basic understanding of how probabilistic graphical models work, and how they can be applied to tasks within natural language processing.</td><td>4,00 Weekly Contact Hours</td></tr>
</table>

Contents:

The course will provide an introduction to probabilistic graphical models, through the lens of natural language processing. Some topics covered will include

- Directed graphical models / Bayesian networks
- Undirected graphical models / Markov random fields
- Conditional random fields
- Causal modeling
- Structured prediction with graphical models
- Inference and sampling from graphical models
- Training methods for graphical models
- Neural graphical models.

Literature:

Klinger, R., & Tomanek, K. (2007). *Classical probabilistic models and conditional random fields*. TU, Algorithm Engineering.

Lafferty, J., McCallum, A., & Pereira, F. (2001, June). Conditional random fields: Probabilistic models for segmenting and labeling sequence data. In Icml (Vol. 1, No. 2, p. 3).

Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep learning*. MIT press.

Examination

Written examination / Duration of Examination: 60 minutes

Module NLProc-Sem1-M Master Seminar Natural Language Processing 1 *Master Seminar Natural Language Processing 1*	3 ECTS / 90 h
(since WS24/25) Person responsible for module: Prof. Dr. Roman Klinger	
Contents: In the seminars of the chair for fundamentals of natural language processing, we discuss advanced and applied topics of natural language processing. These include particular methods for language processing, linguistic properties that are important for modeling, and topics at the intersection to psychology, life sciences and/or social sciences.	
Learning outcomes: The student learns about specialized topics in methods and applications of natural language processing. They acquire this knowledge themselves by reading papers and presenting a condensed form of the information. Students learn to present, critically reflect on topics, and write scientific papers.	
prerequisites for the module: none	
Recommended prior knowledge: none	**Admission requirements:** none

Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Large Language Models for Natural Language Understanding **Mode of Delivery:** Seminar **Language:** English **Frequency:** every winter semester	**2,00 Weekly Contact Hours**
2. Argument Mining **Mode of Delivery:** Seminar **Language:** English/German **Frequency:** every winter semester	**2,00 Weekly Contact Hours**
3. Multi-Modal Language Technology **Mode of Delivery:** Seminar **Language:** English **Frequency:** every winter semester	**2,00 Weekly Contact Hours**
4. Explainable AI Methods and Applications in Natural Language Processing **Mode of Delivery:** Seminar **Language:** English **Frequency:** every winter semester **Learning outcome:** The course aims to examine current research directions on various topics of explainablility in NLP. In particular, we will focus on explaining the inner workings of neural-networks and other models traditionally considered to be "black boxes." Participants will read and discuss research papers, learning to critically question	**0,00 Weekly Contact Hours**

the results presented within, identify gaps in knowledge and develop ideas for further research. **Contents:** Topics include · Bias and bias detection · Model attribution analysis · Interpretability of word embeddings · Attention-based explainability · Adversarial attacks and counterfactuals · Model Debugging and Error Analysis **Literature:** Zhang, Edwin, et al. "Transcendence: Generative Models Can Outperform The Experts That Train Them." *arXiv preprint arXiv:2406.11741* (2024). Li, Jiaoda, Yifan Hou, and Mrinmaya Sachan Ryan Cotterell. "What Do Language Models Learn in Context? The Structured Task Hypothesis." *arXiv e-prints* (2024): arXiv-2406. Goldfarb-Tarrant, Seraphina, et al. "Bias beyond English: Counterfactual tests for bias in sentiment analysis in four languages." *arXiv preprint arXiv:2305.11673* (2023). Marco Ribeiro, Sameer Singh, and Carlos Guestrin. 2016. “Why Should I Trust You?”: Explaining the Predictions of Any Classifier. In Proceedings of the 2016 Conference of the North American Chapter of the Association for Computational Linguistics: Demonstrations, pages 97–101, San Diego, California. Association for Computational Linguistics.	
Examination Internship report	

Module NLProc-Sem2-M Master Seminar Natural Language Processing 2 *Master Seminar Natural Language Processing 2*		3 ECTS / 90 h
(since WS24/25) Person responsible for module: Prof. Dr. Roman Klinger		
Contents: In the seminars of the chair for fundamentals of natural language processing, we discuss advanced and applied topics of natural language processing. These include particular methods for language processing, linguistic properties that are important for modeling, and topics at the intersection to psychology, life sciences and/or social sciences		
Learning outcomes: The student learns about specialized topics in methods and applications of natural language processing. They acquire this knowledge themselves by reading papers and presenting a condensed form of the information. Students learn to present, critically reflect on topics, and write scientific papers.		
prerequisites for the module: none		
Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Multi-Modal Language Technology **Mode of Delivery:** Seminar **Language:** English **Frequency:** every winter semester	**2,00 Weekly Contact Hours**
2. Argument Mining **Mode of Delivery:** Seminar **Language:** English/German **Frequency:** every winter semester	**2,00 Weekly Contact Hours**
3. Large Language Models for Natural Language Understanding **Mode of Delivery:** Seminar **Language:** English **Frequency:** every winter semester	**2,00 Weekly Contact Hours**
4. Explainable AI Methods and Applications in Natural Language Processing **Mode of Delivery:** Seminar **Language:** English **Frequency:** every winter semester **Learning outcome:** The course aims to examine current research directions on various topics of explainablility in NLP. In particular, we will focus on explaining the inner workings of neural-networks and other models traditionally considered to be "black boxes." Participants will read and discuss research papers, learning to critically question	**0,00 Weekly Contact Hours**

the results presented within, identify gaps in knowledge and develop ideas for further research.

Contents:

Topics include

- Bias and bias detection
- Model attribution analysis
- Interpretability of word embeddings
- Attention-based explainability
- Adversarial attacks and counterfactuals
- Model Debugging and Error Analysis

Literature:

Zhang, Edwin, et al. "Transcendence: Generative Models Can Outperform The Experts That Train Them." *arXiv preprint arXiv:2406.11741* (2024).

Li, Jiaoda, Yifan Hou, and Mrinmaya Sachan Ryan Cotterell. "What Do Language Models Learn in Context? The Structured Task Hypothesis." *arXiv e-prints* (2024): arXiv-2406.

Goldfarb-Tarrant, Seraphina, et al. "Bias beyond English: Counterfactual tests for bias in sentiment analysis in four languages." *arXiv preprint arXiv:2305.11673* (2023).

Marco Ribeiro, Sameer Singh, and Carlos Guestrin. 2016. “Why Should I Trust You?”: Explaining the Predictions of Any Classifier. In Proceedings of the 2016 Conference of the North American Chapter of the Association for Computational Linguistics: Demonstrations, pages 97–101, San Diego, California. Association for Computational Linguistics.

Examination

Internship report

Module PSI-AdvaSP-M Advanced Security and Privacy *Advanced Security and Privacy*	6 ECTS / 180 h 45 h Präsenzzeit 135 h Selbststudium
(since SS24) Person responsible for module: Prof. Dr. Dominik Herrmann	

Contents:

Information security and privacy are relevant in almost all information systems today. Many real-world use cases have complex security and privacy requirements involving multiple parties. Often there are multiple stakeholders with different, sometimes even contradictory interests. For instance, some use cases call for a solution that allows a service provider to process sensitive data without learning its content. In other cases it is not the content but some meta information such as location and usage intensity that has to be protected. And then there are scenarios where seemingly harmless pieces of data can be used to disclose or infer very personal pieces of information about an individual.

This module covers advanced techniques for information security and privacy that can be used to satisfy the complex requirements of practical systems. It builds upon the basic concepts in information security that are introduced in the module "Introduction to Security and Privacy" (PSI-IntroSP-B).

Learning outcomes:

This module is designed to bring students towards the research boundaries in the field of security and privacy technologies by covering a selection of contemporary topics in depth. The focus of the module is on technical safeguards that can be used by system designers and users to enforce properties such as confidentiality and integrity. Moreover, sophisticated attacks on security and privacy are explained.

Successful students will be able to explain attack strategies and defenses discussed in recent research papers. They will also be able to analyze whether a particular attack or defense is relevant in a specific scenario. Finally, they will be able to implement selected attacks and defenses with a programming language of their choice.

Remark:

This module is taught in English. It consists of a lecture and tutorials. During the course of the tutorials there will be theoretical and practical assignments (task sheets). Assignments and exam questions can be answered in English or German.

Lecture and tutorials are partially taught in form of a paper reading class. Participants are expected to read the provided literature in advance and participate in the discussions.

Workload breakdown:

- Lecture: 22.5 hours (2 hours per week)
- Tutorials: 22.5 hours (2 hours per week)
- Preparation and studying during the semester: 30 hours
- Assignments: 67.5 hours
- Preparation for the exam (including the exam itself): 37.5 hours

prerequisites for the module:

none

Recommended prior knowledge: Participants should be familiar with basic concepts in information security and privacy, which can be acquired, for instance, by taking the module "Introduction to Security and Privacy" (PSI-IntroSP-B).	**Admission requirements:** none

This includes basic knowledge about the commonly used security terminology, common types of malware and attacks, buffer overflows and related attacks, cryptography, network security, web security, and concepts of privacy. Moreover, participants should have practical experience with at least one scripting or programming language such as Python or Java. Module Introduction to Security and Privacy (PSI-IntroSP-B) - recommended		
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units

1. Advanced Security and Privacy
Mode of Delivery: Lectures
Language: English/German
Frequency: every summer semester

2,00 Weekly Contact Hours

Learning outcome:
cf. module description

Contents:
Selected topics:

- Authentication techniques
- Privacy on the web (e.g., online tracking)
- Privacy enhancing technologies (e.g., Tor)
- Security and privacy aspects of e-mail
- Usability aspects in security and privacy
- Ethical aspects information security
- Advanced techniques in software security (e.g., symbolic execution)
- Advanced cryptographic building blocks
- Other current topics in privacy and security

Some parts of the lecture are aligned with current events and recently published research. The selected topics are therefore subject to change.

Literature:
Selected books:

- R. Anderson: Security Engineering
- A. Shostack: Threat Modelling
- J.-P. Aumasson: Serious Cryptography
- W. Stallings: Computer Security: Principles and Practice
- B. Schneier et al.: Cryptography Engineering
- J. Erickson: Hacking: The Art of Exploitation
- J. Katz & Y. Lindell: Introduction to Modern Cryptography
- L. Cranor & S. Garfinkel: Security and Usability

2. Tutorials for Advanced Security and Privacy
Mode of Delivery: Practicals
Language: English/German

2,00 Weekly Contact Hours

Frequency: every summer semester	

Examination Written examination / Duration of Examination: 110 minutes **Description:** The exam time includes a reading time of 20 minutes. The content that is relevant for the exam consists of the content presented in the lecture and tutorials (including the assignments) as well as the content of the discussed papers. The maximum number of points that can be achieved in the exam is 100. Participants that solve all assignments correctly can collect up to 10 bonus points. Details regarding the number of assignments, the number of points per assignment, and the type of assignments will be announced in the first lecture. If the points achieved in the exam are sufficient to pass the exam on its own (generally, this is the case when at least 50 points have been obtained), the bonus points will be added to the points achieved in the exam. The grade 1.0 can be achieved without the bonus points.	

Module PSI-DiffPriv-M Introduction to Differential Privacy *Introduction to Differential Privacy*	6 ECTS / 180 h
(since WS23/24) Person responsible for module: Prof. Dr. Dominik Herrmann further responsible : Graf, Christian Alexander	

Contents:

The protection of personal data is an organizational as well as a technical challenge. Privacy-by-design is a reasonable requirement that is anything but easy to implement. This is especially true if a system deals with data that is meant to be published.What is more, a mathematically meaningful definition of privacy has only been available for less than a decade.

The lecture addresses different concepts and approaches for de-identification and attacks on privacy of published datasets. Its focus is on bringing you an in-depth understanding of differential privacy. Theoretical foundations, concepts and examples of state-of-the-art algorithms are introduced and explored in greater depth by means of practical exercises.

Contents:

1. Fundamental concepts of Data Privacy (8h)

- Outline of topic and its impact on society and economy
- A short history of data privacy
- Privacy by design and privacy frameworks
- Attacker models and attack patterns
- Different approaches to define privacy and their downsides
- Motivation and conceptual idea of Differential Privacy

2. Mathematical Foundations (20h)

- a review of important concepts from analysis, stochastic and statistics
- properties of important distributions, e.g. Gauss-, Exponential- and Laplace-distribution
- some useful theorems

3. An overview over common methods used in statistical disclosure control (10h)

- common methods used for de-identification and approaches to define privacy in depth
- common methods used for disclosure risk estimation and determination of data utility

4. Algorithmic foundations of Differential Privacy (16h)

- generalized data base models
- randomized algorithms
- mathematical definition and properties of differential privacy
- measuring privacy-loss and utility
- post processing immunity of dp-methods
- alternative dp definitions

5. Different approaches to achieve Differential Privacy (10h)

For instance:

- DIP (distribution invariant differential privacy)

- GAN-approaches
- Existing Software frameworks for de-identification

Learning outcomes:

- understand and apply de-identification approaches and attacks on privacy
- understand and apply fundamental stochastic and statistical methods used in statistical disclosure control
- understand the mathematical concepts of differential privacy following Dwork et. al.
- apply examples for dp-algorithms in example scenarios
- know different approaches towards differential privacy

prerequisites for the module:
none

Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** Semester

Module Units

Lecture and Tutorial — **4,00 Weekly Contact Hours**

Mode of Delivery: Lectures and Practicals
Language: English
Frequency: every winter semester

Contents:
see module description

Literature:
Provisional recommended literature:

- Claire McKay Bowen: Protecting Your Privacy in a Data-Driven World
- Dwork, Roth: The Algorithmic Foundations of Differential Privacy, Foundations and Trends in
- Theoretical Computer Science Vol. 9, Nos. 3–4 (2013)
- SPECIAL ISSUE: A New Generation of Statisticians Tackles Data Privacy, CHANCE Magazine, 33:4, 2020.

Literature on probability theory and statistics:

- Ludwig Fahrmeier, Rita Künstler, Iris Pigeot, Gerhard Tutz, Statistik - Der Weg zur Datenanalyse, 8. Auflage, Springer, 2016.
- William Feller, An Introduction to Probability Theory and Its Applications Vol.I, 3.Auflage, John Wiley & Sons, 1968.
- David J.C. MacKay: Information Theory, Inference, and Learning Algorithms., Cambridge University Press, 2003.

Examination
/ Duration of Examination: 90 minutes

<table>
<tr><td colspan="2">Module PSI-EDS-B Ethics for the Digital Society
Ethics for the Digital Society</td><td>3 ECTS / 90 h</td></tr>
<tr><td colspan="3">(since WS24/25)
Person responsible for module: Prof. Dr. Dominik Herrmann</td></tr>
<tr><td colspan="3">Contents:
This module introduces students to fundamental concepts of ethics and their application to techniques that shape the digital society. It discusses the influence of current and upcoming technologies and their implications from an ethical perspective. The lecture is accompanied by a series of case studies, which focus on a concrete problem that is to be analyzed by the participants. Topics include decision making in autonomous systems and systems that employ so-called artificial intelligence, the reliability and dependability of computer systems, and privacy aspects of information systems.</td></tr>
<tr><td colspan="3">Learning outcomes:
Participants will be able to reflect on their actions as a scientist as well as a computer professional. They learn how to evaluate the trade-offs that are inherent in new technologies and how to design information systems in ways that support the needs of a digital society. Successful participants will obtain the ability to apply ethical thinking to novel problems and potential solutions.</td></tr>
<tr><td colspan="3">Remark:
The module is taught in English unless all participants are fluent in German. There may be a small number of guest lectures that is taught in German.

During the semester multiple case studies will be published. Participants will be asked to submit essays or solutions (small programs) discussing ethical aspects of those case studies. Essays will be peer-reviewed by other participants.</td></tr>
<tr><td colspan="3">prerequisites for the module:
keine</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
keine</td><td>Admission requirements:
none</td></tr>
<tr><td>Frequency: every winter semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
1 Semester</td></tr>
</table>

<table>
<tr><td colspan="2">Module Units</td></tr>
<tr><td>Ethics for the Digital Society
Mode of Delivery: Lectures
Lecturers: Prof. Dr. Dominik Herrmann
Language: English/German
Frequency: every winter semester
<hr>Learning outcome:
cf. module description
<hr>Contents:
cf. module description
<hr>Literature:
Ibo van de Poel and Lamber Royakkers: Ethics, Technology, and Engineering – an Introduction
Jay Quinn: Ethics for the Information Age</td><td>2,00 Weekly Contact Hours</td></tr>
</table>

• Herman T. Tavani: Ethics and Technology: Controversies, Questions, and Strategies for Ethical Computing	

Examination Written examination / Duration of Examination: 80 minutes **Description:** The exam time includes a reading time of 20 minutes. The exam questions will be in English. The questions can be answered in English or German. The content that is relevant for the exam consists of the content presented in the lecture and in the case studies. The maximum number of points that can be achieved in the exam is 100. Participants can collect up to 10 bonus points during the semester. Details regarding the number of assignments, the number of points per assignment, and the type of assignments will be announced in the first lecture. If the points achieved in the exam are sufficient to pass the exam on its own (generally, this is the case when at least 50 points have been obtained), the bonus points will be added to the points achieved in the exam. The grade 1.0 can be achieved without the bonus points.	

Module PSI-IntroSP-B Introduction to Security and Privacy *Introduction to Security and Privacy*	6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Dominik Herrmann	
Contents: This module introduces students to fundamental concepts in the fields of information security and the protection of privacy. It provides a broad overview over the most relevant topics from a technical perspective. The focus lies on practical issues that have to be considered when professional and personal information systems are built and operated.	
Learning outcomes: Successful students will know the mathematical background behind basic cryptographic primitives and be able to explain fundamental concepts of information security and privacy, including classical attacks and defenses. They will be able to apply their knowledge when implementing simple attack programs as well as building and operating defensive techniques.	
Remark: This module is taught in English. It consists of a lecture and tutorials. During the course of the tutorials there will be theoretical and practical assignments (task sheets). Assignments and exam questions can be answered in English or German. Workload breakdown: • Lecture: 22.5 hours (2 hours per week) • Tutorials: 22.5 hours (2 hours per week) • Preparation and studying during the semester: 30 hours • Assignments: 67.5 hours • Preparation for the exam (including the exam itself): 37.5 hours	
prerequisites for the module: none	
Recommended prior knowledge: It is strongly recommended to take this module only after successful completion of introductory courses on computer science on programming, algorithms, data structures, computer architecture, and operating systems. Prospective PSI-IntroSP-B participants should be familiar with fundamentals of computer architecture (binary representation of strings and numbers in computers, bitwise operators (such as XOR), operation of a CPU, basics of assembly language), operating systems (memory layout and process management), and computer networks (basic IP routing and addressing, TCP/IP connection establishment). Also, basic familiarity with the Linux command line is recommended. Moreover, basic familiarity with common web technologies (HTTP, HTML, JavaScript) as well as relational database systems and SQL is a recommended prerequisite.	**Admission requirements:** none

Finally, participants should have working knowledge in at least one programming language (e.g., Python, C, or Java) so that they can write small tools for automation purposes on demand. Module Introduction to Computer Science (Inf-Einf-B) - recommended Module Foundations of Computer Architecture and Operating Systems (Inf-GRABS-B) - recommended	

Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units

1. Introduction to Security and Privacy — **2,00 Weekly Contact Hours**

Mode of Delivery: Lectures
Language: English
Frequency: every winter semester

Learning outcome:
cf. module description

Contents:
Selected topics

- Security Terminology (protection goals, attacker and attack types)
- Authentication and Authorization Fundamentals
- Software Security in C and Assembly (e.g., buffer overflows, selected defenses)
- Cryptography (e.g., historic ciphers, symmetric and asymmetric cryptosystems, Diffie-Hellman key exchange, TLS protocol)
- Network Security (spoofing, denial of service, authentication protocols, intrusion detection systems)
- Web Security (attacks and defenses related to the OWASP Top 10 including SQL injections and Cross Site Scripting)
- Privacy and Techniques for Data Protection (re-identification risks, anonymization networks, k-anonymity, the idea of differential privacy)

Literature:
Selected books:

- A. Shostack: Threat Modelling
- W. Stallings: Computer Security: Principles and Practice
- J. Erickson: Hacking: The Art of Exploitation

2. Introduction to Security and Privacy — **2,00 Weekly Contact Hours**

Mode of Delivery: Practicals
Language: English
Frequency: every winter semester

Contents:
In the tutorials, participants work on tasks and assignments to obtain practical skills related to the information security and privacy topics covered in the lecture.

Examination / Duration of Examination: 90 minutes **Description:** In the intermediate examination (e-exam), participants demonstrate that they master the practical skills acquired by completing the assignments.	

Examination Written examination / Duration of Examination: 120 minutes **prerequisites for module examination:** To be admitted to the final examination (e-exam), participants must have passed the intermediate exam (e-exam). **Description:** The exam time includes a reading time of 30 minutes. Details about the requirements for admission to the written examination will be announced in the first lecture. The content that is relevant for the exam consists of the content presented in the lecture and tutorials. The exam questions are in English. The exam questions can be answered in English or German.	

Module PSI-ProjectCAD-M Project Complex Attacks and Defenses *Project Complex Attacks and Defenses*	9 ECTS / 270 h

(since SS24)
Person responsible for module: Prof. Dr. Dominik Herrmann

Contents:

Breaking into information systems is exciting, but impractical due to ethical and legal concerns. However, offensive competences and adversarial thinking are essential to build secure systems. In this project students will get the opportunity to acquire practical security skills in a dedicated training environment.

The goal of this project is to build and extend the "Insekta" platform. This web-based tool provides a frontend for virtual machines that can be used to study selected topics in security and privacy on one's own and at one's own pace.

This project is offered together with PSI-ProjectPAD, which focuses on conceptually simpler attacks and defenses.

The participants of the project familiarize themselves with security weaknesses in information systems and apply this knowledge to develop vulnerable services which others can use for training. To this end, participants form groups, read about attacks and defenses in textbooks and research papers, and discuss various options to implement them. Instructors will provide extensive and on-demand support to enable the participants to implement a vulnerable service that can be exploited to learn about a particular vulnerability.

Besides implementing vulnerable services, the participants prepare training materials, which consist of questions and tasks to test one's knowledge as well as step-by-step instructions. These training materials may also contain interactive elements for an improved learning experience.

The project also takes into account attacks on privacy, e.g., re-identifying individuals in anonymized datasets and communication networks, tracking users on the Internet, inferring sensitive attributes from seemingly harmless data traces, as well as mitigations, e.g., depersonalization strategies and differential privacy mechanisms. Here, practical activities consist in the preparation of datasets and scripts for analysis.

Learning outcomes:

Successful students will be able to describe attacks and defenses from textbooks and research papers in easily understandable form. They will also be able to carry out selected attacks in practice and implement defenses with a programming language of their choice.

Remark:

This project is taught in English, unless all participants are fluent in German. The workload of this project is equivalent to 270 hours.

Workload breakdown:

- 20 hrs: Getting familiar with the platform
- 50 hrs: Reading papers and researching security vulnerabilities
- 20 hrs: Preparing the talk (including time for attendance of other talks)
- 90 hrs: Implementing the vulnerable service and defenses
- 90 hrs: Writing training material and documentation

Note that there is another project (PSI-ProjectPAD) with a workload equivalent to 180 hours.

prerequisites for the module: none		
Recommended prior knowledge: This project is primarily intended for students in master programs. Students in bachelor programs can participate, if they are qualified. Participants should be familiar with basic concepts in information security and privacy, which can be acquired, for instance, by taking the module "Introduction to Security and Privacy" (PSI-IntroSP-B). This includes basic knowledge about the commonly used security terminology, common types of malware and attacks, buffer overflows and related attacks, cryptography, network security, web security, and concepts of privacy. Moreover, participants should have practical experience with at least one scripting or programming language such as Python or Java. Experience with Linux environments, web technologies, and network protocols is recommended.		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Project Complex Attacks and Defenses **Mode of Delivery:** **Language:** English/German **Frequency:** every semester **Learning outcome:** cf. module description **Contents:** Potential topics include: • web security (injection flaws and other issues mentioned in the OWASP Top 10) • network security (such as DNS cache poisoning and rebinding attacks) • security issues in C programs (buffer overflows, etc.) • cryptography (low-level attacks on ciphers, high-level attacks on protocols, e.g., TLS) • business logic failures • misconfigurations • attacks on availability (denial of service) • attacks on privacy (such as inference, tracking, re-identification, fingerprinting) • privacy defenses (such as k-anonymity, related concepts, differential privacy) **Literature:** Literature will be announced at the beginning of the project.	**6,00 Weekly Contact Hours**

Examination Coursework Assignment and Colloquium / Duration of Examination: 30 minutes Duration of Coursework: 3 months **prerequisites for module examination:** Regular attendance at project meetings. **Description:** The module examination consists of two parts: Firstly, the participants submit a written report (in English) that includes the source code of the vulnerable service and the training material. Secondly, the participants give a talk in which they defend their work (in English; in German if all participants are fluent in German) by presenting theoretical and practical aspects of their vulnerable service as well as relevant mitigations. The maximum number of points that can be achieved in the module examination is 100. Optionally, participants can submit intermediary results (in English) to collect up to 20 bonus points. If the module examination is passed on its own (generally, this is the case when at least 50 points are obtained), the bonus points will be added to the points achieved in the module examination. The grade 1.0 can be achieved without the bonus points. Details regarding the number of optional submissions during the semester, their type, the points per submission, and the respective deadlines will be announced in the first session of the project.	

Module PSI-ProjectPAD Project Practical Attacks and Defenses *Project Practical Attacks and Defenses*	6 ECTS / 180 h
(since SS24) Person responsible for module: Prof. Dr. Dominik Herrmann	

Contents:

Breaking into information systems is exciting, but impractical due to ethical and legal concerns. However, offensive competences and adversarial thinking are essential to build secure systems. In this project students will get the opportunity to acquire practical security skills in a dedicated training environment.

The goal of this project is to build and extend the "Insekta" platform. This web-based tool provides a frontend for virtual machines that can be used to study selected topics in security and privacy on one's own and at one's own pace.

This project is offered together with PSI-ProjectCAD-M, which focuses on conceptually more complex attacks and defenses.

The participants of the project familiarize themselves with security weaknesses in information systems and apply this knowledge to develop vulnerable services which others can use for training. To this end, participants form groups, read about attacks and defenses in textbooks and research papers, and discuss various options to implement them. Instructors will provide extensive and on-demand support to enable the participants to implement a vulnerable service that can be exploited to learn about a particular vulnerability.

Besides implementing vulnerable services, the participants prepare training materials, which consist of questions and tasks to test one's knowledge as well as step-by-step instructions. These training materials may also contain interactive elements for an improved learning experience.

The project also takes into account attacks on privacy, e.g., re-identifying individuals in anonymized datasets and communication networks, tracking users on the Internet, inferring sensitive attributes from seemingly harmless data traces, as well as mitigations, e.g., depersonalization strategies and differential privacy mechanisms. Here, practical activities consist in the preparation of datasets and scripts for analysis.

Learning outcomes:

Successful students will be able to describe attacks and defenses from textbooks and research papers in easily understandable form. They will also be able to carry out selected attacks in practice and implement defenses with a programming language of their choice.

Remark:

This project is taught in English, unless all participants are fluent in German. The workload of this project is equivalent to 180 hours.

Workload breakdown:

- 10 hrs: Getting familiar with the platform
- 30 hrs: Reading papers and researching security vulnerabilities
- 15 hrs: Preparing the talk (including time for attendance of other talks)
- 70 hrs: Implementing the vulnerable service and defenses
- 55 hrs: Writing training material and documentation

Note that there is another project (PSI-ProjectCAD-M) with a workload equivalent to 270 hours.

prerequisites for the module: none		
Recommended prior knowledge: Students in bachelor and master programs can participate in this project. Participants should be familiar with basic concepts in information security and privacy, which can be acquired, for instance, by taking the module "Introduction to Security and Privacy" (PSI-IntroSP-B). This includes basic knowledge about the commonly used security terminology, common types of malware and attacks, buffer overflows and related attacks, cryptography, network security, web security, and concepts of privacy. Moreover, participants should have practical experience with at least one scripting or programming language such as Python or Java. Experience with Linux environments, web technologies, and network protocols is recommended.		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Project Practical Attacks and Defenses **Mode of Delivery:** **Language:** English/German **Frequency:** every semester **Learning outcome:** cf. module description **Contents:** Potential topics include: • web security (injection flaws and other issues mentioned in the OWASP Top 10) • network security (such as DNS cache poisoning and rebinding attacks) • security issues in C programs (buffer overflows, etc.) • cryptography (low-level attacks on ciphers, high-level attacks on protocols, e.g., TLS) • business logic failures • misconfigurations • attacks on availability (denial of service) • attacks on privacy (such as inference, tracking, re-identification, fingerprinting) • privacy defenses (such as k-anonymity, related concepts, differential privacy) **Literature:** Literature will be announced at the beginning of the project.	**4,00 Weekly Contact Hours**

Examination Coursework Assignment and Colloquium / Duration of Examination: 30 minutes Duration of Coursework: 3 months **prerequisites for module examination:** Regular attendance at project meetings. **Description:** The module examination consists of two parts: Firstly, the participants submit a written report (in English) that includes the source code of the vulnerable service and the training material. Secondly, the participants give a talk in which they defend their work (in English; in German if all participants are fluent in German) by presenting theoretical and practical aspects of their vulnerable service as well as relevant mitigations. The maximum number of points that can be achieved in the module examination is 100. Optionally, participants can submit intermediary results (in English) to collect up to 20 bonus points. If the module examination is passed on its own (generally, this is the case when at least 50 points are obtained), the bonus points will be added to the points achieved in the module examination. The grade 1.0 can be achieved without the bonus points. Details regarding the number of optional submissions during the semester, their type, the points per submission, and the respective deadlines will be announced in the first session of the project.	

Module PSI-ProjectSP-M Project Security and Privacy *Project Security and Privacy*		6 ECTS / 180 h
(since SS24) Person responsible for module: Prof. Dr. Dominik Herrmann		
Contents: In this project participants work independently on problems related to current research activities of the Privacy and Security in Information Systems Group. Instructors will provide guidance and supervision.		
Learning outcomes: Successful students will be able to independently work on research problems in security and privacy. They will also be able to implement tools and/or analyze data in order to answer a research question. Finally, they will be able to present their work in a talk and document their approach and results in a written report.		
Remark: This project is taught in English unless all participants are fluent in German. The workload of this project is equivalent to 270 hours. Workload breakdown: • 60 hrs: Getting familiar with the problem and preliminaries: reading related work, and understanding potentially existing source code • 20 hrs: Preparing the talk (including time for attendance of other talks) • 110 hrs: Implementing tools and/or analyzing data • 80 hrs: Writing final report with approach and methods		
prerequisites for the module: none		
Recommended prior knowledge: Participants should have advanced knowledge and practical skills in information security and privacy, which can be acquired, for instance, in the module PSI-IntroSP-B and a security-related seminar or project. Depending on the actual topic participants may be expected to be familiar with commonly used security terminology, common types of malware and attacks, buffer overflows and related attacks, cryptography, network security, web security, and concepts of privacy. Moreover, participants should have practical experience with at least one scripting or programming language such as Python or Java. Alternatively, participants should have strong skills in empirical data collection and data analytics (statistics and/or machine learning). Experience with Linux environments, web technologies, and network protocols is recommended.		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Project Security and Privacy **Mode of Delivery:** **Language:** English/German	**6,00 Weekly Contact Hours**

Frequency: every semester

Learning outcome:
cf. module description

Contents:
Potential topics include

- empirical studies, either manually (surveying security properties of systems) or automatically (e.g., web crawls),
- creating scanning tools and platforms where results can be published in a meaningful way (e.g., PrivacyScore.org),
- analyzing data sets for aspects of security and privacy, and
- implementing cryptographic or anonymization techniques in a secure fashion, e.g., for encrypted storage in cloud services.

Literature:
Literature will be announced at the beginning of the project.

Examination
Coursework Assignment and Colloquium / Duration of Examination: 30 minutes
Duration of Coursework: 3 months
prerequisites for module examination:
Regular attendance at project meetings.
Description:
The module examination consists of two parts: Firstly, the participants submit a written report (in English) that includes the source code, datasets, and analysis scripts. Secondly, the participants give a talk in which they defend their work (in English; in German if all participants are fluent in German) by presenting related work, their approach, and results. The maximum number of points that can be achieved in the module examination is 100.

Optionally, participants can submit intermediary results (in English) to collect up to 20 bonus points. If the module examination is passed on its own (generally, this is the case when at least 50 points are obtained), the bonus points will be added to the points achieved in the module examination. The grade 1.0 can be achieved without the bonus points. Details regarding the number of optional submissions during the semester, their type, the points per submission, and the respective deadlines will be announced in the first session of the project.

Module PSI-SSSProject-B Software Systems Science Project: Security and Privacy *Software Systems Science Project: Security and Privacy*	12 ECTS / 360 h
(since SS24) Person responsible for module: Prof. Dr. Dominik Herrmann	

Contents:

This project is specifically offered for Software Systems Science students. The participants of the project familiarize themselves with security and privacy issues that arise during the development of information systems.

Potential tasks during the project include the development of training scenarios for the Insekta platform, designing and/or participating in "build it – break it – fix it" challenges, and contributing to ongoing research activities of members of the Privacy and Security in Information Systems Group. Typically, participants work on their project in small groups. They carry out required research (mostly) on their own, reading about attacks and defenses in textbooks and research papers. Instructors will provide extensive and on-demand support to enable the participants.

Students who are interested in this project may approach a member of the PSI group in order to learn about currently available topics.

Learning outcomes:

Successful students will be able to explain attacks and defenses from textbooks and research papers. They will also be able to carry out selected attacks in practice and implement defenses with a programming language of their choice.

Remark:

This project is taught in English, unless all participants are fluent in German. The workload of this project is equivalent to 360 hours (spread over two semesters).

Workload breakdown:

- 20 hrs: Getting familiar with the task, obtaining preliminary knowledge
- 60 hrs: Reading papers and researching security vulnerabilities
- 30 hrs: Preparing the talks (including time for attendance of other talks)
- 200 hrs: Implementation
- 50 hrs: Writing project report

Note that there are other projects (PSI-ProjectCAD-M, PSI-ProjectPAD, PSI-ProjectSP-M) with different workloads.

prerequisites for the module:

none

Recommended prior knowledge:	**Admission requirements:**
Participants should be familiar with basic concepts in information security and privacy, which can be acquired, for instance, by taking the module "Introduction to Security and Privacy" (PSI-IntroSP-B). This includes basic knowledge about the commonly used security terminology, common types of malware and attacks, buffer overflows and related attacks, cryptography, network security, web security, and concepts of privacy.	none

Moreover, participants should have practical experience with at least one scripting or programming language such as Python or Java. Experience with Linux environments, web technologies, and network protocols is recommended.		
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 2 Semester

Module Units	
Software Systems Science Project: Security and Privacy **Mode of Delivery:** **Language:** English/German **Frequency:** every semester **Learning outcome:** cf. module description **Contents:** cf. module description **Literature:** Literature will be announced at the beginning of the project.	**8,00 Weekly Contact Hours**

Examination Coursework Assignment and Colloquium / Duration of Examination: 30 minutes Duration of Coursework: 3 months **prerequisites for module examination:** Regular attendance **Description:** The module examination consists of two module examination segments. The respective weights of the two module examination segments will be announced at the beginning of the semester in which the project starts. The second segment of the module examination consists of two parts: Firstly, the participants submit a written report (in English) that includes any source code, datasets, and analysis scripts. Secondly, the participants give a talk in which they defend their work (in English; in German if all participants are fluent in German) by presenting related work, their approach, and results. The maximum number of points that can be achieved in the module examination is 100. Optionally, participants can submit intermediary results (in English) to collect up to 20 bonus points. If this part of the module examination is passed on its own (generally, this is the case when at least 50 points are obtained), the bonus points will be added to the points achieved in this part of the module examination. The grade 1.0 can be achieved without the bonus points. Details regarding the number of optional submissions during the semester, their type, the points per submission, and the respective deadlines will be announced in the first session of the project.	

Module PSI-Sem-B Seminar Security and Privacy Foundations *Seminar Security and Privacy Foundations*		3 ECTS / 90 h
(since WS24/25) Person responsible for module: Prof. Dr. Dominik Herrmann		
Contents: This seminar covers various topics related to information security and privacy. A list of available topics will be published on the website of the Privacy and Security in Information Systems Group before the first session of the seminar. Participants will form small groups and work on one of the topics.		
Learning outcomes: Participants will learn to search for, read, and discuss scientific literature in the subject area of information security and privacy. They will also learn how to write scientific texts and how to present their findings.		
Remark: This seminar will be offered in English unless all participants speak German.		
prerequisites for the module: none		
Recommended prior knowledge: Basic knowledge in the area of computer science (e.g. as covered in the module EiRBS) are helpful, but not required. Module Introduction to Computer Science (Inf-Einf-B) - recommended		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Seminar Security and Privacy Foundations **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Dominik Herrmann **Language:** English/German **Frequency:** every semester **Learning outcome:** cf. module description **Contents:** cf. module description **Literature:** Relevant literature will be provided when the topics are assigned.	**2,00 Weekly Contact Hours**

Examination Internship report / Duration of Examination: 30 minutes Duration of Coursework: 2 months **prerequisites for module examination:** Continuous attendance in the seminar sessions is mandatory, cf. §9 (10) APO. **Description:**	

Participants write a seminar thesis and give a talk summarizing their findings.	

<table>
<tr><td colspan="2">Module PSI-Sem-M Seminar Research Topics in Security and Privacy
Seminar Research Topics in Security and Privacy</td><td>3 ECTS / 90 h</td></tr>
<tr><td colspan="3">(since WS24/25)
Person responsible for module: Prof. Dr. Dominik Herrmann</td></tr>
<tr><td colspan="3">Contents:
This seminar provides in-depth coverage of advanced topics in one of the fields of information security and privacy.

Participants learn to review, analyze, and discuss scientific sources (books and essays). While participants are expected to perform the actual research independently and mostly on their own, the instructors provide extensive support throughout the seminar. The instructors will provide guidance on scientific methods, e.g., how to approach a topic, how to find relevant literature, how to read a paper efficiently, how to write a seminar report, and how to give a good talk.

Participants will be asked to deliver manageable chunks of work throughout the semester (such as summarizing literature in a survey, writing a draft of the term paper, etc.).

The actual topics are subject to change. A list of available topics is made available before the first session via the seminar's VC course.</td></tr>
<tr><td colspan="3">Learning outcomes:
The participants learn to find, read, and summarize scientific texts. They also learn to assess statements and to discuss them critically. Finally, they learn to write scientific texts and to present their results in a talk.</td></tr>
<tr><td colspan="3">Remark:
The default language in this seminar is English, unless all participants are fluent in German.</td></tr>
<tr><td colspan="3">prerequisites for the module:
none</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
Participants should have basic knowledge in software engineering, foundations of computing, operating systems, and networks. Knowledge in information security and privacy (obtained, e.g., in PSI-IntroSP-B and by having completed a seminar or thesis in the field of information security) is strongly recommended.</td><td>Admission requirements:
none</td></tr>
<tr><td>Frequency: every semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
1 Semester</td></tr>
</table>

<table>
<tr><td colspan="2">Module Units</td></tr>
<tr><td>Seminar Research Topics in Security and Privacy
Mode of Delivery: Seminar
Language: English/German
Frequency: every winter semester<hr>Contents:
cf. module description<hr>Literature:
• Alley: The Craft of Scientific Writing</td><td>2,00 Weekly Contact Hours</td></tr>
</table>

• Anderson: Security Engineering • Pfleeger et al.: Security in Computing • Stallings & Brown: Computer Security: Principles and Practice • Strunk & White: The Elements of Style Other relevant literature is presented in the first session.	

Examination Internship report / Duration of Examination: 30 minutes Duration of Coursework: 2 months **prerequisites for module examination:** Continuous attendance in the seminar sessions is mandatory, cf. §9 (10) APO. **Description:** The module examination consists of two parts, a term paper (in English) and a talk (in English; in German if all participants are fluent in German). The maximum number of points that can be achieved in the module examination is 100. Details regarding the number of points that can be achieved in the talk and in the report will be announced in the first session of the project. Optionally, participants can participate in writing and presentation labs, where they can submit intermediary results (in English) or give mock presentations (in English). Participants can thereby earn 20 bonus points. If the module examination is passed on its own (generally, this is the case when at least 50 points are obtained), the bonus points will be added to the points achieved in the module examination. The grade 1.0 can be achieved without the bonus points.	

<table>
<tr><td colspan="2">Module SNA-ASN-M Social Network Analysis
Analyse sozialer Netzwerke</td><td>6 ECTS / 180 h</td></tr>
<tr><td colspan="3">(since SS23)
Person responsible for module: Prof. Dr. Oliver Posegga</td></tr>
<tr><td colspan="3">Contents:
Social network analysis focuses on relationships between or among social entities. This course presents an introduction to various concepts, methods, and applications of social network analysis. The primary focus of these methods is the analysis of relational data measured on populations of social actors.</td></tr>
<tr><td colspan="3">Learning outcomes:
Erwerb vertiefter Kenntnisse der Methoden und Modelle der Netzwerkanalyse. Die Studierenden verstehen die Bedeutung der Struktur sozialer Netzwerke für die Effektivität und Effizienz betrieblicher Arbeitsprozesse. Sie erlernen methodische Grundlagen der Analyse sozialer Netzwerke und die Bewertung ihrer strukturellen Eigenschaften. Sie sind in der Lage, ihre Kenntnisse auf Forschungsfragen der Wirtschaftsinformatik anzuwenden.</td></tr>
<tr><td colspan="3">Remark:
The language of instruction in this course is German. However, the exam is available in English.</td></tr>
<tr><td colspan="3">prerequisites for the module:
none</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
keine</td><td>Admission requirements:
keine</td></tr>
<tr><td>Frequency: every winter semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
1 Semester</td></tr>
</table>

<table>
<tr><td colspan="2">Module Units</td></tr>
<tr><td>1. Analyse sozialer Netzwerke
Mode of Delivery: Lectures
Lecturers: Prof. Dr. Oliver Posegga
Language: German
Frequency: every winter semester
Contents:
Topics include an introduction to graph theory and the use of directed graphs and matrices to study actor interrelations; structural and locational properties of actors, such as centrality, prestige, and prominence; subgroups and cliques; equivalence of actors, including structural equivalence and, blockmodels;local analyses, including dyadic and triad analysis; and introduction to statistical global analyses, using models such as p* and their relatives. Methods are illustrated on a wide range of social network examples using both standard social network analysis software and special purpose computer programs.
Literature:
• Carrington PJ, Scott J, Wasserman S (2005) Models and Methods in Social Network Analysis. Cambridge University Press, New York.
• Knoke D, Yang S (2007) Social Network Analysis, 2. Auflage. Sage Publications, Thousand Oaks</td><td>2,00 Weekly Contact Hours</td></tr>
</table>

• Newman MEJ (2010) Networks. An Introduction. Oxford University Press, Oxford. • Wasserman S, Faust K (1994) Social Network Analysis: Methods and Applications. Cambridge University Press, New York.	
2. Analyse sozialer Netzwerke **Mode of Delivery:** Practicals **Lecturers:** Scientific Staff Wirtschaftsinformatik, insb. Soziale Netzwerke **Language:** German **Frequency:** every winter semester **Contents:** Die Inhalte der Vorlesung werden anhand von Übungsaufgaben und Fallbeispielen vertieft. Praktische Übungen werden unter Verwendung gängiger Software wie beispielsweise R und Gephi zur Analyse sozialer Netzwerke durchgeführt. **Literature:** • De Nooy, W., Mrvar, A., & Batagelj, V. (2018). Exploratory social network analysis with Pajek: Revised and expanded edition for updated software (Vol. 46). Cambridge university press. • Grandjean, M. (2015). Gephi: Introduction to network analysis and visualization. • Luke, D. A. (2015). A user's guide to network analysis in R (Vol. 72, No. 10.1007, pp. 978-3). New York: Springer.	**2,00 Weekly Contact Hours**

Examination Written examination / Duration of Examination: 90 minutes **Description:** In der Klausur werden die in Vorlesung und Übung behandelten Inhalte geprüft. Es können 90 Punkte erzielt werden. Durch die freiwillige Abgabe von semesterbegleitenden Studienleistungen können Punkte zur Notenverbesserung gesammelt werden, die auf die Klausur anrechenbar sind, sofern die Klausur auch ohne Punkte aus Studienleistungen bestanden ist. Zu Beginn der Lehrveranstaltung wird bekannt gegeben, ob Studienleistungen angeboten werden. Falls Studienleistungen angeboten werden, wird zu diesem Zeitpunkt auch die Anzahl, die Art, der Umfang und die Bearbeitungsdauer der Studienleistungen sowie die Anzahl an erreichbaren Punkten pro Studienleistung bekannt gegeben. Eine Bewertung von 1,0 kann auch ohne Punkte aus den Studienleistungen erreicht werden.	

Module SNA-NET-M Network Theory *Netzwerktheorie*	6 ECTS / 180 h	
(since SS23) Person responsible for module: Prof. Dr. Oliver Posegga		
Contents: Individuals and technology shape and are shaped by organizations. Individuals and organizations are also affected by sets of interlinked networks linking people, technology, organizations, knowledge and resources. In this world of networks and organizations, how do coordination, communication, power, tasks, goals, and information interact to affect group and organizational behavior and the impact of information technology on this behavior? How do we conceptualize, measure, and evaluate organizations and networks? How do we evaluate the impact of policies and technology on these organizations and networks especially given the fact that organizations and networks are dynamic?		
Learning outcomes: Die Studierenden kennen interdisziplinäre Theoriebeiträge zur Erklärung der Struktur und Dynamik sozialer Netzwerke und können das erworbene Wissen auf relevante Forschungsfragen der Wirtschaftsinformatik anwenden. Sie verstehen den Einfluss der Struktur eines Netzwerkes auf seine internen Prozesse und die Veränderung der Struktur eines Netzwerkes im Zeitverlauf. Themenfelder: • Theorien sozialer und komplexer Netzwerke • Emergenz und Dynamik sozialer Netzwerke • Agentenbasierte Modellierung und Spieltheorie • Informationsverarbeitung in sozialen Netzwerken • Netzwerkprozesse • Wissensnetzwerke		
Remark: The language of instruction in this course is German. However, the exam is available in English.		
prerequisites for the module: none		
Recommended prior knowledge: Kenntnisse aus dem Modul Analyse sozialer Netzwerke sind wünschenswert, jedoch nicht Voraussetzung		**Admission requirements:** keine
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Netzwerktheorie **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Oliver Posegga **Language:** German **Frequency:** every summer semester **Contents:** This course provides an overview of the dominant perspectives on organizations and networks from a macro perspective. Topics covered include knowledge	**2,00 Weekly Contact Hours**

management, organizational design, organizational learning, organizational evolution and population ecology, organizational culture, organizations as complex systems, social and organizational networks, and dynamic network analysis. **Literature:** • Easley D, Kleinberg J (2010) Networks, Crowds, and Markets. Reasoning about a Highly Connected World. Cambridge University Press, New York • Goyal S (2009) Connections: An Introduction to the Economics of Networks, Princeton University Press, Princeton und Oxford • Jackson MO (2008) Social and Economic Networks. Princeton University Press, Princeton und Oxford • Kilduff M, Tsai W (2003) Social Networks and Organizations. Sage Publications, Thousand Oaks • Monge PR, Contractor N (2003) Theories of Communication Networks. Oxford University Press, New York	
2. Netzwerktheorie **Mode of Delivery:** Practicals **Lecturers:** Scientific Staff Wirtschaftsinformatik, insb. Soziale Netzwerke **Language:** German **Frequency:** every summer semester **Contents:** Die Inhalte der Vorlesung werden anhand von Übungsaufgaben und Fallbeispielen vertieft. Praktische Übungen werden unter Verwendung gängiger Software zur Analyse sozialer Netzwerke durchgeführt. **Literature:** Siehe Vorlesung.	**2,00 Weekly Contact Hours**

Examination Written examination / Duration of Examination: 90 minutes **Description:** In der Klausur werden die in Vorlesung und Übung behandelten Inhalte geprüft. Es können 90 Punkte erzielt werden. Durch die freiwillige Abgabe von semesterbegleitenden Studienleistungen können Punkte zur Notenverbesserung gesammelt werden, die auf die Klausur anrechenbar sind, sofern die Klausur auch ohne Punkte aus Studienleistungen bestanden ist. Zu Beginn der Lehrveranstaltung wird bekannt gegeben, ob Studienleistungen angeboten werden. Falls Studienleistungen angeboten werden, wird zu diesem Zeitpunkt auch die Anzahl, die Art, der Umfang und die Bearbeitungsdauer der Studienleistungen sowie die Anzahl an erreichbaren Punkten pro Studienleistung bekannt gegeben. Eine Bewertung von 1,0 kann auch ohne Punkte aus den Studienleistungen erreicht werden.	

Module SNA-OSN-M Project Online Social Networks *Projekt zu Online Social Networks*		6 ECTS / 180 h
(since SS23) Person responsible for module: Prof. Dr. Oliver Posegga		
Contents: This module is an introduction to the analysis of online social networks. The aim is twofold: to provide students with the tools necessary to undertake research into online networks, and to give an overview of the type of questions these data can answer.		
Learning outcomes: At the conclusion of the course, students should know not only how to calculate basic network metrics on pre-existing data sets, but also how to capture an online social network efficiently with the intent of answering a specific research question. Further goals: • Learn how the radical innovation process in small teams works • Learn how to collaborate in multidisciplinary intercultural virtual teams • Learn how to find trendsetter and trends on the Internet and social media • Learn how to predict trends using SNA und statistical forecasting techniques		
Remark: The main language of instruction in this course is English. The written reports/seminar essay and the presentation have to be delivered in English.		
prerequisites for the module: none		
Recommended prior knowledge: We recommend attending at least one of the following courses: • Social Network Analysis (SNA-ASN-M) • Theories of Social Networks (SNA-NET-M)		**Admission requirements:** keine
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Online Social Networks **Mode of Delivery:** Practicals **Lecturers:** Prof. Dr. Oliver Posegga **Language:** English/German **Frequency:** every winter semester **Contents:** The course will define online networks, examine how they differ from offline social networks, and consider theoretical and methodological issues associated with their analysis. The sessions will explore different strategies to retrieve and analyze online network data, and present different empirical scenarios to which those tools have been applied. **Literature:**	**4,00 Weekly Contact Hours**

• Gloor, P. A. Swarm Creativity, Competitive Advantage Through Collaborative Innovation Networks. Oxford University Press, 2006 Further literature will be announced in the lecture.	

Examination Coursework Assignment and Colloquium / Duration of Examination: 30 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regelmäßige Teilnahme an der Lehrveranstaltung **Description:** Die Gewichtung der Prüfungsleistungen Hausarbeit und Kolloquium wird zu Beginn der Lehrveranstaltung von der Dozentin bzw. dem Dozenten bekannt gegeben.	

Module SNA-WIM-B Knowledge- and Informationmanagement *Wissens- und Informationsmanagement*		6 ECTS / 180 h
(since SS23) Person responsible for module: Prof. Dr. Oliver Posegga		
Contents: Die Veranstaltung bietet eine Einführung in das betriebliche Wissens- und Informationsmanagement.		
Learning outcomes: Ziel der Veranstaltung ist die Vermittlung folgender Kenntnisse und Fähigkeiten: • Studierende kennen und verstehen relevante Begriffe, Modelle und Theorien des Wissens- und Informationsmanagements. • Studierende können die Modelle und Theorien zur Analyse und Bewertung verschiedener Wissens- und Informationsmanagementaspekte anwenden. • Studierende kennen verschiedene Wissens- und Informationsmanagementsysteme, die im inner- und überbetrieblichen Bereich zum Einsatz kommen. • Studierende verstehen, wie Wissensmanagementsysteme geeignet gestaltet und genutzt werden können. • Studierende verstehen die Bedeutung sozialer Netzwerke für das Wissensmanagement.		
prerequisites for the module: none		
Recommended prior knowledge: none		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Wissens- und Informationsmanagement **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Oliver Posegga **Language:** German **Frequency:** every summer semester	**2,00 Weekly Contact Hours**
Contents: Vor dem Hintergrund der Globalisierung und Digitalisierung sowie der damit einhergehenden Intensivierung und Diversifizierung der Vernetzung erlangt das effektive und effiziente Management der Ressourcen Information und Wissen in Unternehmen strategischen Rang. Die Lehrveranstaltung befasst sich in diesem Kontext mit Zielen, Aufgaben, Systemen, Theorien und Methoden des Wissens- und Informationsmanagements. Dazu werden unter anderem die Wissensentwicklung, -verteilung, -nutzung, -bewertung, -bewahrung sowie der Wissenserwerb innerhalb von Unternehmen betrachtet.	
Literature:	

Dalkir, K. (2017): Knowledge Management in Theory and Practice. (3. Auflage). Cambridge, Massachusetts: The MIT Press. Weitere Literatur wird in der Veranstaltung bekannt gegeben.	
2. Wissens- und Informationsmanagement **Mode of Delivery:** Practicals **Lecturers:** Scientific Staff Wirtschaftsinformatik, insb. Soziale Netzwerke **Language:** German **Frequency:** every summer semester **Contents:** Die Übung Wissens- und Informationsmanagement dient der Vertiefung, Übung und Anwendung des in der Vorlesung vermittelten Stoffs. Dazu werden Aufgaben und Methoden des Wissens- und Informationsmanagements behandelt und Fallstudien in Gruppen bearbeitet. **Literature:** siehe Vorlesung	**2,00 Weekly Contact Hours**

Examination Written examination / Duration of Examination: 90 minutes **Description:** Durch die freiwillige Abgabe von semesterbegleitenden Studienleistungen können Punkte zur Notenverbesserung gesammelt werden, die auf die Klausur anrechenbar sind, sofern die Klausur auch ohne Punkte aus Studienleistungen bestanden ist. Zu Beginn der Lehrveranstaltung wird bekannt gegeben, ob Studienleistungen angeboten werden. Falls Studienleistungen angeboten werden, werden zu diesem Zeitpunkt auch die Anzahl, die Art, der Umfang und die Bearbeitungsdauer der Studienleistungen sowie die Anzahl an erreichbaren Punkten pro Studienleistung und in der Modulprüfung bekannt gegeben. Eine Bewertung von 1,0 kann auch ohne Punkte aus den Studienleistungen erreicht werden.	

Module SWT-ASV-M Applied Software Verification *Applied Software Verification*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Gerald Lüttgen		
Contents: This module focuses on the increasingly important field of automated software verification, which aims at increasing the quality of today's complex computer systems. Students will be introduced to modern automated software verification and, in particular, to software model checking, and will be familiarised with a variety of important formal verification concepts, techniques and algorithms, as well as with state-of-the-art verification tools.		
Learning outcomes: On completion of this module, students will be able to thoroughly analyse software using modern software verification tools and understand the state-of-the-art techniques and algorithms that drive cutting-edge development environments offered by major software companies.		
Remark: The main language of instruction is English. The lectures and practicals may be delivered in German if all participating students are fluent in German. The total workload of 180 hrs. is split approximately as follows: • 30 hrs. attending lectures (Vorlesungen) • 30 hrs. attending practicals (Übungen) • 60 hrs. preparing and reviewing the lectures and practicals, including researching literature, studying material from additional sources and applying software tools • 30 hrs. working on the assignment (Hausarbeit) • 30 hrs. preparing for the colloquium (Kolloquium)		
prerequisites for the module: none		
Recommended prior knowledge: Basic knowledge in algorithms and data structures, mathematical logic and theoretical computer science.		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Applied Software Verification **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Gerald Lüttgen **Language:** English **Frequency:** every summer semester **Contents:** The lectures (Vorlesungen) will address the following topics in automated software verification: (i) state machines, linear-time properties and algorithms for state space exploration; (ii) LTL model checking; (iii) SAT solving and bounded model checking; (iv) decision procedures and SMT solving; (v) software	**2,00 Weekly Contact Hours**

model checking; (vi) predicate abstraction. In addition, state-of-the-art software verification tools will be introduced. **Literature:** • Baier, C., Katoen, J.-P. Principles of Model Checking. MIT Press, 2008. • Clarke, E., Grumberg, O., Kroening, D., Peled, D. and Veith, H. Model Checking. 3rd. ed. MIT Press, 2018. • Huth, M. and Ryan, M. Logic in Computer Science. 2nd ed. Cambridge University Press, 2004. • Kroening, D. and Strichman, O. Decision Procedures: An Algorithmic Point of View. Springer, 2008. • Loeckx, J. and Sieber, K. The Foundations of Program Verification. 2nd ed. Wiley, 1987.	
2. Applied Software Verification **Mode of Delivery:** Practicals **Lecturers:** Scientific Staff Praktische Informatik, insbesondere Softwaretechnik und Programmiersprachen **Language:** English **Frequency:** every summer semester **Contents:** Students will practice the various theoretical and practical concepts taught in the lectures (Vorlesungen) by applying them to solve verification problems using several modern model-checking tools, and also by engaging in pen-and-paper exercises. Emphasis will be put on presenting and discussing the solutions to the exercises by and among the students, within the timetabled practicals (Übungen). **Literature:** - see the corresponding lectures -	**2,00 Weekly Contact Hours**

Examination Coursework Assignment and Colloquium / Duration of Examination: 20 minutes Duration of Coursework: 3 weeks **Description:** Assignment (Hausarbeit) consisting of questions that practice, review and deepen the knowledge transferred in the lectures and practicals (Vorlesungen und Übungen). The assignment is set in English language, while answers may be provided in either English or German. Colloquium (Kolloquium) consisting of questions testing the knowledge transferred in the lectures and practicals (Vorlesungen und Übungen), on the basis of the submitted solutions to the assignment (Hausarbeit). The colloquium can be held electively in English or German language.	

Module SWT-FPS-B Foundations of Program Semantics *Foundations of Program Semantics*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Gerald Lüttgen		
Contents: This theory module offers students a mathematical perspective on sequential, imperative computer programs and concurrent, distributed software. It studies the formal semantics of programs which enables their analysis and verification.		
Learning outcomes: On completion of this module, students will be able to understand and apply core foundational concepts of, and techniques behind, program semantics and software, in the context of both sequential and concurrent systems.		
Remark: The main language of instruction is English. The lectures and practicals may be delivered in German if all participating students are fluent in German. The total workload of 180 hrs. is split approximately as follows: • 60 hrs. attending lectures (Vorlesungen) • 30 hrs. attending practicals (Übungen) • 60 hrs. preparing and reviewing the lectures and practicals, including researching literature, studying material from additional sources • 30 hrs. working on the assignment (Hausarbeit) and preparing for the colloquium (Kolloquium)		
prerequisites for the module: none		
Recommended prior knowledge: Basic knowledge in discrete mathematics, logics and algebra.		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Foundations of Software Analysis **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Gerald Lüttgen **Language:** English/German **Frequency:** every winter semester	**4,00 Weekly Contact Hours**
Contents: Students will be introduced to the foundations of program semantics and their applications to program verification. Particular emphasis will be put on mathematical theories for reasoning about sequential and concurrent systems. The following topics will be covered: Part I: Mathematical Foundations • Inductive definitions and proofs • Orders, functions and fixed points	

- Algebraic structures, equivalences and congruences
- Algebraic laws and logic systems

Part II: Sequential, Imperative Programs

- The imperative language IMP
- Natural, structural operational and denotational semantics
- The Hoare calculus

Part III: Concurrent, Distributed Software

- The process calculus CCS
- Strong and weak bisimulation
- Algebraic laws and axiomatization

Literature:

- Bruni, R. and Montanari, U., Models of Computation. Springer, 2017.
- Milner, R. Communication and Concurrency. Prentice Hall, 1989.
- Nielson, H. R. and Nielson, F., Semantics with Applications: An Appetizer. Springer, 2007.
- Loeckx, J. and Sieber, K. The Foundations of Program Verification, 2nd ed. Wiley, 1987.
- Steffen, B., Rüthing, O. and Huth, M. Mathematical Foundations of Advanced Informatics. Springer, 2018.
- Davey, B. A. and Priestley, H. A. Introduction to Lattices and Order, 2nd ed. Cambridge University Press, 2002.

2. Foundations of Software Analysis **Mode of Delivery:** Practicals **Lecturers:** Scientific Staff Praktische Informatik, insbesondere Softwaretechnik und Programmiersprachen **Language:** English/German **Frequency:** every winter semester **Contents:** The practicals (Übungen) cover pen-and-paper exercises that will deepen the concepts and techniques taught in the lectures (Vorlesungen), and apply them to the analysis and verification of small examples of software. Emphasis will be put on presenting and discussing the solutions to the exercises by and among the students. **Literature:** - see the corresponding lectures -	**2,00 Weekly Contact Hours**
Examination Coursework Assignment and Colloquium / Duration of Examination: 20 minutes Duration of Coursework: 3 weeks **Description:** Assignment (Hausarbeit) consisting of questions practicing, reviewing and deepening the knowledge transferred in the lectures and practicals (Vorlesungen und Übungen). The assignment is set in English; students may answer in either English or German.	

Colloquium (Kolloquium) consisting of questions testing the knowledge transferred in the lectures and practicals (Vorlesungen und Übungen), on the basis of the submitted solutions to the assignment (Hausarbeit). The examination language is either English or German and may be chosen by the student at the colloquium.	

Module SWT-FSE-B Foundations of Software Engineering *Foundations of Software Engineering*		6 ECTS / 180 h
(since SS23) Person responsible for module: Prof. Dr. Gerald Lüttgen		
Contents: This module teaches the foundations of software engineering that are applicable to various kinds of software systems – from information systems to embedded systems. It focusses on technologies, notations and processes for system specification, design, implementation, and verification and validation.		
Learning outcomes: Students will receive an introduction to the common problems and paradigms in, and foundations of, software development. They will also gather conceptional and practical knowledge in the analysis, design and testing of software, with an emphasis on technical aspects of specifying, designing, implementing, verifying and validating software.		
Remark: The main language of instruction is English. The lectures and practicals may be delivered in German if all participating students are fluent in German. The total workload of 180 hrs. is split approximately as follows: • 45 hrs. attending lectures (Vorlesungen) • 30 hrs. reviewing the lectures, including researching and studying material from additional sources • 45 hrs. attending practicals (Übungen) • 30 hrs. preparing and reviewing the practicals, including researching and studying material from additional sources • 30 hrs. preparing for the written exam (Klausur)		
prerequisites for the module: none		
Recommended prior knowledge: Basic knowledge in Computer Science, as well as knowledge in programming in Java and in algorithms and data structures.		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Foundations of Software Engineering **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Gerald Lüttgen **Language:** English/German **Frequency:** every summer semester	**3,00 Weekly Contact Hours**
Contents: The lectures (Vorlesungen) provide an introduction to the foundations of software engineering, including commonly used technologies, notations and processes for all software engineering phases. In particular, conceptual and technical aspects of software specification, architecture and design, and verification and validation	

are discussed, such as the Unified Modeling Language (UML) and its semantics, model-driven and pattern-based development, and software testing. Students are also introduced to specific aspects of agile software development. **Literature:** • Sommerville, I. Software Engineering, 10th ed. Pearson, 2016. • Robertson, S. and Robertson, J. Mastering the Requirements Process, 3rd ed. Addison-Wesley, 2012. • Cohn, M. User Stories Applied. Addison-Wesley, 2004. • Stevens, P. and Pooley, R. Using UML - Software Engineering with Objects and Components, 2nd ed. Addison-Wesley, 2006. • Freeman, E., Robson, E., Sierra, K. and Bates, B. Head First Design Patterns, 2nd ed. O'Reilly, 2020. • Gamma, E., Helm, R., Johnson, R. and Vlissides, J. Design Patterns: Elements of Reusable Object-Oriented Design. Prentice Hall, 1994. Further literature will be announced in the lectures.	
2. Foundations of Software Engineering **Mode of Delivery:** Practicals **Lecturers:** Prof. Dr. Gerald Lüttgen, Scientific Staff Praktische Informatik, insbesondere Softwaretechnik und Programmiersprachen **Language:** English/German **Frequency:** every summer semester **Contents:** The practicals (Übungen) exercise and deepen the conceptual knowledge transferred via the lectures (Vorlesungen), and relay practical knowledge in software engineering. **Literature:** - see the corresponding lectures -	**3,00 Weekly Contact Hours**

Examination Written examination / Duration of Examination: 120 minutes **Description:** Written exam (Klausur) consisting of questions that relate to the contents of the lectures (Vorlesungen) and practicals (Übungen) of this module. The written exam is set in English, while answers may be provided in either English or German. The exam is passed if at least 50% of the available points are reached.	

Module SWT-PR1-M Masters Project in Software Engineering and Programming Languages *Masterprojekt Softwaretechnik und Programmiersprachen*	6 ECTS / 180 h

(since WS24/25)
Person responsible for module: Prof. Dr. Gerald Lüttgen

Contents:
Topics in Software Engineering and Programming Languages are carried out individually or in teams of students, from conception, via theoretical and/or practical realization, to evaluation. In particular, the project concerns the development of sound concepts pertaining to the task to be addressed under the given project constraints. This requires studying academic literature and relevant technologies and approaches on the project's topic.

An example of a project task would be the conceptual development, the prototypic implementation, and the case-study-driven evaluation of tools for software verification, which requires the prior attendance of the module "Applied Software Verification" (SWT-ASV-M), or equivalent knowledge.

Learning outcomes:
Students will deepen their knowledge regarding the conceptual problems that arise when carrying out scientific projects related to Software Systems Science, and regarding approaches to possible solutions. Students will also gain important experience in carrying out such projects, from project planning, to the abstract and concrete design, to the realization, to the documentation of results in a scientific project report.

Remark:
The main language of instruction is English. The module may be delivered in German if all participating students are fluent in German. A regular participation in the project meetings is necessary.

The total workload of 180 hrs. is split approximately as follows:

- 10 hrs. participating in introductions to and tutorials on methods, software tools, and giving presentations on the project status
- 20 hrs. completing the exercises for bonus points
- 115 hrs. researching and familiarization with the project topic and conducting the project work
- 35 hrs. compilating a project report (written assignment/schriftliche Hausarbeit) and preparation of the Colloquium (Kolloquium).

prerequisites for the module:
none

Recommended prior knowledge: Basic knowledge in software engineering and programming languages, knowledge in the subject matter of the project topic.		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Masters Project in Software Engineering and Programming Languages **Mode of Delivery:**	**4,00 Weekly Contact Hours**

Lecturers: Prof. Dr. Gerald Lüttgen, Scientific Staff Praktische Informatik, insbesondere Softwaretechnik und Programmiersprachen **Language:** English/German **Frequency:** every semester	
Learning outcome: To be announced at the beginning of the project.	
Contents: Conduct of the project, accompanied by tutorials and regular project meetings.	
Literature: To be announced at the beginning of the project.	

Examination Coursework Assignment and Colloquium, schriftliche Hausarbeit mit Kolloquium / Duration of Examination: 20 minutes Duration of Coursework: 12 weeks **prerequisites for module examination:** Regelmäßige Teilnahme an den zugehörigen Lehrveranstaltungen **Description:** Production of a written report on the software project carried out (written assignment/schriftliche Hausarbeit). The student may choose whether to write/ compose the project report in English or German. Discussion of this project report and of the developed artefacts in the context of the wider project topic (Colloquium/Kolloquium). The examination language is either English or German and may be chosen by the student at the colloquium.	

<table>
<tr><td colspan="2">Module SWT-SEM-B Seminar in Software Engineering and Programming Languages (Bachelor)
Seminar Software Engineering and Programming Languages (Bachelor)</td><td>3 ECTS / 90 h</td></tr>
<tr><td colspan="3">(since WS24/25)
Person responsible for module: Prof. Dr. Gerald Lüttgen</td></tr>
<tr><td colspan="3">Contents:
Current topics in software engineering and programming languages.</td></tr>
<tr><td colspan="3">Learning outcomes:
Students will compile and acquire current topics in software engineering and programming languages by carrying out and documenting a guided literature survey, and by preparing and delivering a coherent, comprehensible presentation to their peers.</td></tr>
<tr><td colspan="3">Remark:
The main language of instruction is English. The seminar may be delivered in German if all participating students are fluent in German. Regular participation in the presentations is required.

The total workload of 90 hrs. is split approximately as follows:
• 20 hrs. consultations and presentations (Referate), including discussions
• 25 hrs. literature research and familiarization and evaluation of literature
• 45 hrs. working on the assignment (schriftliche Hausarbeit) and preparation for the presentation (Referat)</td></tr>
<tr><td colspan="3">prerequisites for the module:
none</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
Basic knowledge in software engineering and in programming languages.</td><td>Admission requirements:
none</td></tr>
<tr><td>Frequency: every summer semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
1 Semester</td></tr>
</table>

<table>
<tr><td colspan="2">Module Units</td></tr>
<tr><td>Software Engineering and Programming Languages (Bachelor)
Mode of Delivery: Seminar
Lecturers: Prof. Dr. Gerald Lüttgen, Scientific Staff Praktische Informatik, insbesondere Softwaretechnik und Programmiersprachen
Language: English/German
Frequency: every summer semester
<hr>Contents:
Various current topics in software engineering and programming languages, which complement and/or extend the technical and methodological aspects of the degree programme's modules related to these fields.
<hr>Literature:
Literature will be allocated according to the topics to be discussed.</td><td>2,00 Weekly Contact Hours</td></tr>
</table>

Examination Internship report / Duration of Examination: 40 minutes Duration of Coursework: 8 weeks **prerequisites for module examination:** Regular participation in the seminar. **Description:** Presentation (Referat) on the topic assigned to the student, including a discussion. Assignment (schriftliche Hausarbeit) consisting of a written report on the topic assigned to the student.	

Module SWT-SEM-M Seminar in Software Engineering and Programming Languages (Master) *Seminar Software Engineering and Programming Languages (Master)*	3 ECTS / 90 h	
(since WS24/25) Person responsible for module: Prof. Dr. Gerald Lüttgen		
Contents: Current topics in software engineering and programming languages. This may comprise the full spectrum of research topics in these fields, from the analysis, comparison and evaluation of current software technologies and tools, to the discussion and evaluation of novel research proposals.		
Learning outcomes: Students will compile and acquire current topics in software engineering and programming languages by independently carrying out and documenting a literature survey, and by preparing and delivering a coherent, comprehensible presentation to their peers. Students will also be able to scientifically discuss topics in software engineering and programming languages with their peers.		
Remark: The main language of instruction is English. The seminar may be delivered in German if all participating students are fluent in German. Regular participation in the presentations is required. The total workload of 90 hrs. is split approximately as follows: • 20 hrs. consultations and presentations (Referate), including discussions • 25 hrs. literature research and familiarization and evaluation of literature • 45 hrs. working on the assignment (schriftliche Hausarbeit) and preparation for the presentation (Referat)		
prerequisites for the module: none		
Recommended prior knowledge: Basic knowledge in software engineering, in programming languages and in the subject matter of the seminar. Additionally, basic knowledge of scientific methods is expected.		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Software Engineering and Programming Languages (Master) **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Gerald Lüttgen, Scientific Staff Praktische Informatik, insbesondere Softwaretechnik und Programmiersprachen **Language:** English/German **Frequency:** every summer semester **Contents:** Various current topics in software engineering and programming languages, which complement and/or extend the technical and methodological aspects of the degree programme's modules related to these fields. **Literature:**	**2,00 Weekly Contact Hours**

Will be allocated according to the topics to be discussed.	

Examination Internship report / Duration of Examination: 40 minutes Duration of Coursework: 8 weeks **prerequisites for module examination:** Regular participation in the seminar. **Description:** Presentation (Referat) on the topic assigned to the student, including a discussion. Assignment (schriftliche Hausarbeit) consisting of a written report on the topic assigned to the student.	

Module SWT-SWL-B Software Engineering Lab *Software Engineering Lab*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Gerald Lüttgen		
Contents: Small teams of students will conduct a software project, starting from a brief problem description. This involves the application of modern software engineering tools, skills in collaboration and team organisation, and knowledge of processes and techniques for producing software artefacts and associated documents.		
Learning outcomes: Students will develop a piece of medium-sized software in small teams, thereby acquiring practical expertise in software engineering and skills in working in a software development team. In addition, this module deepens the students' programming proficiency and their understanding of flexible software engineering processes and of software and process quality, and familiarises them with the deployment and use of modern software engineering tools.		
Remark: The main language of instruction is English. The practicals may be delivered in German if all participating students are fluent in German. A regular attendance of team meetings and active participation is required throughout. The total workload of 180 hrs. is split approximately as follows: • 20 hrs. attending meetings of the student's team with the lecturer (Dozent) on planning, coordination and feedback • 10 hrs. attending the accompanying practicals/tutorials (Übungen/Tutorials) on software tools • 130 hrs. conducting the team project • 20 hrs. working on the written assignment (schriftliche Hausarbeit) and preparing for the colloquium (Kolloquium)		
prerequisites for the module: none		
Recommended prior knowledge: Basic knowledge in Computer Science and Software Engineering, as well as knowledge in Java programming and in programming in the small.		**Admission requirements:**
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Software Engineering Lab **Mode of Delivery:** **Lecturers:** Prof. Dr. Gerald Lüttgen, Scientific Staff Praktische Informatik, insbesondere Softwaretechnik und Programmiersprachen **Language:** German/English **Frequency:** every winter semester **Contents:**	**4,00 Weekly Contact Hours**

Each team will carry out a software project, regularly meet with their tutor (Dozent) in order to critically reflect on the team's work, and participate in tutorials that introduce the software engineering tools and some software engineering techniques to be used in this project. **Literature:** • Tudose, C., Tahchiev, P., Leme, F., Massol, V. and Gregory, G. JUnit in Action, 3rd ed. Manning Publications, 2020. • Loeliger, J. and McCullough, M. Version Control with Git: Powerful Tools and Techniques for Collaborative Software Development, 2nd ed. O'Reilly, 2012. • Vogel, L. Eclipse IDE. Lars Vogel, 2013. ISBN 3943747042. • Schwaber, K. and Beedle, M. Agile Software Development with Scrum, Pearson, 2001. • Cohn, M. User Stories Applied. Addison-Wesley, 2004. See the description of the module "Foundations of Software Engineering (SWT-FSE-B)" for further literature.	
Examination Coursework Assignment and Colloquium, schriftliche Hausarbeit mit Kolloquium / Duration of Examination: 45 minutes Duration of Coursework: 2 weeks **prerequisites for module examination:** Regular participation in the associated practicals, including the participation in programming tasks. **Description:** Written assignment (schriftliche Hausarbeit) involving the compilation of a written project report in English or German language by each team, which shall cover the following topics: • A description of the team’s produced artefacts, plus the electronic submission of the artefacts themselves; • A description, justification and critical reflection of the employed software engineering processes, methods and techniques in general and in each development phase; • A description of the team’s organisation, the distribution of work and the contributions of each team member. The submission deadline and the details of the required content and format of this report will be announced at the beginning of the semester. Colloquium (Kolloquium) consisting of a critical discussion of the team's produced software and project report with respect to the taken design decisions and possible alternatives, the quality of the produced artefacts and documentation, the project's status and completeness, the conduct of testing, and the appropriateness of the employed techniques and processes. The colloquium takes place in the presence of the team as a whole, but each question will be addressed to a specific student so that marks can be individualised. The colloquium can be held electively in English or German language. Because this module involves a team effort, the examination can only be resit in a winter semester.	

Module SYSNAP-OSE-M Operating Systems Engineering *Operating Systems Engineering*	6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Michael Engel	

Contents:

Operating systems and related system software such as hypervisors form the basis of today's computer systems. The design and implementation of the core parts of system software can have significant impact not only on the performance of a computer system, but also on other aspects such a safety, security, and energy efficiency. Thus, the design and implementation of operating systems is a highly relevant topic for students working in all areas of computer science, from small embedded systems to large virtualized Cloud infrastructures.

This module concentrates on the central part ("kernel") of an operating system, i.e. the part of the system running in a privileged processor mode that interacts directly with hardware. Based on seminal publications, students will investigate different architectures of kernels, such as monolithic, micro- and exokernels, hypervisors and also unikernels. Mechanisms and policies of operating systems will be analyzed with respect to their functional as well as non-functional properties. The analysis of mechanisms dependent on a specific processor architecture will be explained using the modern and open RISC-V processor architecture.

A central part of this module will consist of code reading and the development of pieces of code for a small operating system. Different aspects of operating system functionality will be demonstrated through existing code. Constraints of, extension possibilities for, as well as alternative approaches to implement a given functionality will be discussed; this discussion will then form the basis for the implementation of a given feature in the practical exercises. An example for this is the discussion of file systems; here, features of a given traditional inode-based file system will be discussed and analyzed and alternative implementations, such as log-structured file systems, will be investigated and implemented in a basic form.

Learning outcomes:

The module is designed to enable students to not only understand the internals of operating systems, but also learn about different aspects of their implementation and the interaction between hardware and software. Starting from a thorough analysis of the internals of modern operating systems, this module will continue to present and discuss novel and non-traditional approaches to operating systems in the second half of the semester.

Successful students will be able to understand design and implementation aspects of system software as well as to comprehend and critically analyze proposed new approaches from the literature. They will also be able to understand the structure of and extend a given operating system code base with new functionality and test as well as evaluate functional and non-functional properties of the implementation. By writing system-level code running directly on hardware (or a hardware emulator), students will also be able to gain a better understanding of the operation of hardware and its interaction with software.

prerequisites for the module:

none

Recommended prior knowledge:	**Admission requirements:**
Participants should be familiar with basic concepts of operating systems and computer architecture, e.g. as acquired by	-

taking the module "Grundlagen der Rechnerarchitektur und Betriebssysteme" (Inf-GRABS-B). In addition, knowledge of C programming, debugging using gdb, using the Unix command line, and software construction tools (e.g. make) are useful.		
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Vorlesung Operating Systems Engineering **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Michael Engel **Language:** German/English **Frequency:** every summer semester **Learning outcome:** cf. module description **Contents:** cf. module description **Literature:** • Russ Cox, Frans Kaashoek and Robert Morris, "xv6: a simple, Unix-like teaching operating system", MIT PDOS group 2020, https://pdos.csail.mit.edu/6.S081/2020/xv6/book-riscv-rev1.pdf • Zhao Jiong, "A Heavily Commented Linux Source code", http://www.oldlinux.org/download/ECLK-5.0-WithCover.pdf • Marshall Kirk McKusick et al., "The Design and Implementation of the 4.4 BSD Operating System", Addison-Wesley 1996, ISBN-13: 978-0132317924 • Uresh Vahalia, "Unix: the New Frontiers", Pearson 1996, ISBN-13: 978-0131019089 • John Lions, "Commentary on the 6th Edition Unix System", 1977, https://warsus.github.io/lions-/ • David Patterson and Andrew Waterman, "The RISC-V Reader: An Open Architecture Atlas", Strawberry Canyon 2017, ISBN-13: 978-0999249116$ • Andrew Waterman, Krste Asanovic and John Hauser (eds.), "The RISC-V Instruction Set Manual Volume II: Privileged Architecture", Document Version 20211203, https://github.com/riscv/riscv-isa-manual/releases/download/Priv-v1.12/riscv-privileged-20211203.pdf In addition, selected papers will be provided.	**2,00 Weekly Contact Hours**
2. Übung Operating Systems Engineering **Mode of Delivery:** **Lecturers:** Prof. Dr. Michael Engel **Language:** German/English **Frequency:** every summer semester **Learning outcome:** cf. module description **Contents:**	**2,00 Weekly Contact Hours**

cf. module description	

Examination Coursework Assignment and Colloquium / Duration of Examination: 30 minutes Duration of Coursework: 3 months **Description:** Oral examination concerning the topics discussed in the lecture, exercises and assignment. Students may choose English or German as the language for the oral examination. Examinations will take place at the end of the summer term or at the begin of the winter term (students may choose one of them). Students are assumed to work on a programming assignment ('schriftliche Hausarbeit') during the semester that is introduced at the beginning of the semester and uses the most important technologies discussed during the semester. **Note:** Without working on the programming assignment over the term students may run into problems during their oral examination (Kolloquium) as we discuss questions concerning topics from the lectures as well as from the assignment; questions about the assignment are based on the assignment solution programmed by the students.	

Module SYSNAP-Project-B Project Systems Programming *Projekt Systemnahe Programmierung*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Michael Engel		
Contents: Students work (in groups) on a small yet realistic project to develop a standalone piece of system software that is not solvable in acceptable time by a single student. Hence, besides • basic literature research to find approaches to solve the problem(s) at hand and to get used to the state-of-the-art technology required, • analyzing, designing, architecting, programming and testing the practical solution, skills such as planning, delegating and organizing work in groups are practiced. Note: The topics of this master project are - compared to bachelor projects - more advanced and lead to advanced skills in the development of operating systems, machine-level and assembler programming as well as debugging.		
Learning outcomes: Students learn how to • work independently and in groups on selected problems using the knowledge and skills provided by other modules, • work with state-of-the-art tools and refer to recent scientific literature to look for problem solutions, • architect and implement an operating system kernel interacting with emulators and real hardware, • read, understand and apply data sheets as well as processor and peripheral user manuals • document and present their work in an understandable manner to others, • interact with others to discuss pros and cons of different solution approaches, • organize work in groups, esp., how to delegate work, to fix interfaces and work under time constraints.		
prerequisites for the module: none		
Recommended prior knowledge: Module Inf-GRABS-B		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Projekt Systemnahe Programmierung **Mode of Delivery:** **Lecturers:** Prof. Dr. Michael Engel **Language:** German/English **Frequency:** every semester **Learning outcome:** see module description **Contents:** see module description	**4,00 Weekly Contact Hours**

Literature: Based on the concrete project topics literature will be provided at the start of the semester.	
Examination Coursework Assignment and Colloquium / Duration of Examination: 30 minutes Duration of Coursework: 3 months **prerequisites for module examination:** As this is a project in groups and the topic of the examination is the project work of each student, each student has to declare which part of the project and report is due to his own work. **Description:** Project report and developed software based on the project work indicating which are the on achievements during the project. Oral examination concerning the technologies used in the project as well as the work of the group a student belongs to with an emphasis on her or his own work.	

Module SYSNAP-Project-M Project Systems Programming *Projekt Systemnahe Programmierung*	6 ECTS / 180 h
(since SS24) Person responsible for module: Prof. Dr. Michael Engel	

Contents:

Students work (in groups) on a small yet realistic project to develop a standalone piece of system software that is not solvable in acceptable time by a single student. Hence, besides

- basic literature research to find approaches to solve the problem(s) at hand and to get used to the state-of-the-art technology required,
- analyzing, designing, architecting, programming and testing the practical solution,

skills such as planning, delegating and organizing work in groups are practiced.
Note: The topics of this master project are - compared to bachelor projects - more advanced and lead to advanced skills in the development of operating systems, machine-level and assembler programming as well as debugging.

Learning outcomes:

Students learn how to

- work independently and in groups on selected problems using the knowledge and skills provided by other modules,
- work with state-of-the-art tools and refer to recent scientific literature to look for problem solutions,
- architect and implement an operating system kernel interacting with emulators and real hardware,
- read, understand and apply data sheets as well as processor and peripheral user manuals
- document and present their work in an understandable manner to others,
- interact with others to discuss pros and cons of different solution approaches,
- organize work in groups, esp., how to delegate work, to fix interfaces and work under time constraints.

prerequisites for the module:

none

Recommended prior knowledge: Modules SYSNAP-OSE and/or SYSNAP-Virt		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Projekt Systemnahe Programmierung **Mode of Delivery:** **Lecturers:** Prof. Dr. Michael Engel **Language:** German/English **Frequency:** every semester	**4,00 Weekly Contact Hours**
Learning outcome: see module description	
Contents: see module description	

Literature: Based on the concrete project topics literature will be provided at the start of the semester.	
Examination Coursework Assignment and Colloquium / Duration of Examination: 30 minutes Duration of Coursework: 3 months **prerequisites for module examination:** As this is a project in groups and the topic of the examination is the project work of each student, each student has to declare which part of the project and report is due to his own work. **Description:** A project report written in the style of a scientific publication is required. Master students are also expected to write reviews of their fellow students' papers in a round of peer review. In addition, delivery of the developed software based on the project work indicating which are the on achievements during the project. Oral examination concerning the technologies used in the project as well as the work of the group a student belongs to with an emphasis on her or his own work.	

Module SYSNAP-SEM-B Seminar System Software *Seminar System Software*		3 ECTS / 90 h
(since SS24) Person responsible for module: Prof. Dr. Michael Engel		
Contents: Current topics in system software, including operating systems, hypervisors, just-in-time compilation and hardware-software interfacing. Topics cover the full spectrum of research topics in these fields, from the analysis, design, implementation and evaluation of current system software, to the discussion and evaluation of novel research proposals. Bachelor students will also receive material about working with scientific literature, the use of scientific methods, as well as preparing the seminar report and presentation.		
Learning outcomes: Students will compile and acquire current topics in operating systems by independently carrying out and documenting a literature survey, and by preparing and delivering a coherent, comprehensible presentation to their peers. Students will also be able to scientifically discuss topics in system software with their peers.		
Remark: Participation in the LaTeX course organized by the Fachschaft WIAI is recommended.		
prerequisites for the module: none		
Recommended prior knowledge: Basic knowledge in system software, machine-level programming and computer architecture and in the subject matter of the seminar.		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Seminar **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Michael Engel **Language:** German/English **Frequency:** every semester **Learning outcome:** cf. module description **Contents:** cf. module description **Literature:** Recent papers on system software related to the respective focus of the seminar, announced at the start of the semester.	**2,00 Weekly Contact Hours**
Examination Internship report / Duration of Examination: 30 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regular participation in the group meetings	

Description: Review of a written elaboration on the most important aspects of the topic, including a correct list of references. Participation in peer reviewing the other participants; free holding of a a presentation based on presentation documents including discussion of the contents with the seminar participants.	

Module SYSNAP-SEM-M Seminar System Software *Seminar System Software*		3 ECTS / 90 h
(since SS24) Person responsible for module: Prof. Dr. Michael Engel		
Contents: Current topics in system software, including operating systems, hypervisors, just-in-time compilation and hardware-software interfacing. Topics cover the full spectrum of research topics in these fields, from the analysis, design, implementation and evaluation of current system software, to the discussion and evaluation of novel research proposals.		
Learning outcomes: Students will compile and acquire current topics in operating systems by independently carrying out and documenting a literature survey, and by preparing and delivering a coherent, comprehensible presentation to their peers. Students will also be able to scientifically discuss topics in system software with their peers.		
prerequisites for the module: none		
Recommended prior knowledge: Basic knowledge in system software, machine-level programming and computer architecture and in the subject matter of the seminar. Additionally, basic knowledge of scientific methods is expected.		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Seminar **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Michael Engel **Language:** German/English **Frequency:** every semester **Learning outcome:** cf. module description **Contents:** cf. module description **Literature:** Recent papers on system software related to the respective focus of the seminar, announced at the start of the semester.	**2,00 Weekly Contact Hours**
Examination Internship report / Duration of Examination: 30 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regular participation in the group meetings **Description:** Review of a written elaboration on the most important aspects of the topic, including a correct list of references.	

Participation in peer reviewing the other participants; free holding of a a presentation based on presentation documents including discussion of the contents with the seminar participants.	

Module SYSNAP-Virt-M Virtualization *Virtualisierung*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Michael Engel		
Contents: Virtualization is the basis of a significant part of the Internet infrastructure today. It is used in different contexts such as system-level virtualization for co-hosting virtual machines in Cloud infrastructures or just-in-time translation of JavaScript code in web applications. This module discusses virtualization technologies on all layers of the hardware/software stack, from system-level virtualization to virtual machines for high-level languages. Based on publications and real-world code examples, students will investigate different architectures of virtual machines. The design and implementation of virtualization technologies will be analyzed through the investigation of real-world open-source code examples for common hardware, such as x86, ARM and RISC-V.		
Learning outcomes: The module is designed to enable students to understand the different approaches to virtualization and learn details about their design and implementation. Students will learn to analyze the advantages and disadvantages of virtualization on different layers of a computer system and will gain experience in isolation and security properties of virtualized systems. Successful students will be able to understand design and implementation aspects of different virtualization approaches as well as to comprehend and critically analyze proposed new approaches from the literature. They will also be able to understand the structure of and extend a given virtualization system code base with new functionality and test as well as evaluate functional and non-functional properties of the implementation.		
prerequisites for the module: none		
Recommended prior knowledge: Participants should be familiar with basic concepts of operating systems and computer architecture, e.g. as acquired by taking the module "Grundlagen der Rechnerarchitektur und Betriebssysteme" (Inf-GRABS-B). In addition, knowledge of C programming, debugging using gdb, using the Unix command line, and software construction tools (e.g. make) are useful.		**Admission requirements:** -
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Vorlesung Virtualisierung **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Michael Engel **Language:** German/English **Frequency:** every winter semester **Learning outcome:** c.f. module description **Contents:**	**2,00 Weekly Contact Hours**

c.f. module description **Literature:** • Jim Smith and Ravi Nair, Virtual Machines: Versatile Platforms for Systems and Processes Morgan Kaufmann, 1st edition 2005, ISBN-13: 978-1558609105 • Steven Hand, Andrew Warfield, Keir Fraser, Evangelos Kotsovinos, Dan Magenheimer Are Virtual Machine Monitors Microkernels Done Right? Proceedings of HotOS'05, 2005 • Gernot Heiser, Volkmar Uhlig and Joshua LeVasseur, Are virtual-machine monitors microkernels done right?, ACM SIGOPS Oper. Syst. Rev., vol. 40, number 1, 2006 • Barham, Paul, et al., Xen and the art of virtualization, ACM SIGOPS operating systems review 37.5 (2003): 164-177 • Heiser, Gernot, and Kevin Elphinstone. L4 microkernels: The lessons from 20 years of research and deployment, ACM Transactions on Computer Systems (TOCS) 34.1 (2016): 1-29 • Engler, Dawson R., M. Frans Kaashoek, and James O'Toole Jr., Exokernel: An operating system architecture for application-level resource management, ACM SIGOPS Operating Systems Review 29.5 (1995): 251-266 • Aycock, John, A brief history of just-in-time, ACM Computing Surveys (CSUR) 35.2 (2003): 97-113 Additional selected papers will be provided as required.	
2. Übung Virtualisierung **Mode of Delivery:** **Lecturers:** Prof. Dr. Michael Engel **Language:** German/English **Frequency:** every winter semester **Learning outcome:** c.f. module description **Contents:** c.f. module description	**2,00 Weekly Contact Hours**

Examination Coursework Assignment and Colloquium / Duration of Examination: 30 minutes Duration of Coursework: 3 months **Description:** Oral examination concerning the topics discussed in the lecture, exercises and assignment. Students may choose English or German as the language for the oral examination. Examinations will take place at the end of the winter term or at the begin of the summer term (students may choose one of them).	

Students are assumed to work on a programming assignment ('schriftliche Hausarbeit') during the semester that is introduced at the beginning of the semester and uses the most important technologies discussed during the semester.	

Module VIS-IVVA-M Advanced Information Visualization and Visual Analytics *Advanced Information Visualization and Visual Analytics*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Fabian Beck		
Contents: The course discusses methods for interactive information visualization and systems for explorative visual analysis. Visualizations blend with algorithmic solutions and get adopted to domain-specific needs. Giving a research-oriented perspective, the design and evaluation of such methods is the focus of the course, as well as their practical and interdisciplinary application in various fields.		
Learning outcomes: The students recognize the possibilities and limitations of data visualization and are able to apply visualization methods to concrete application examples. They understand the foundations of visual perception and cognition as well as their implications for the visual representation of data. They have a sound overview of possibilities for the visual representation of abstract data and are able to adapt visualization techniques to new problems and justify design decisions. On a conceptual level, they are able to integrate visualization techniques with interaction techniques and algorithmic solutions and design visual analytics solutions. They can evaluate visualization techniques in quantitative and qualitative user studies.		
Remark: The workload for this module typically is as follows: • Lecture and exercise sessions: 45h • Preparation and review of the lecture: 30h • Work on exercises and assignments: 75h • Preparation for the exam: 30h		
prerequisites for the module: none		
Recommended prior knowledge: Basic knowledge in information visualization (e.g., as provided through VIS-GIV-B) is recommended; knowledge in programming, algorithms and data structures, human-computer-interaction, and machine learning and data science can be beneficial.		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Advanced Information Visualization and Visual Analytics **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Fabian Beck **Language:** English **Frequency:** every winter semester **Contents:** See module description	**2,00 Weekly Contact Hours**

Literature: Further material and reading will be announced in the course.	
2. Advanced Information Visualization and Visual Analytics **Mode of Delivery:** Practicals **Lecturers:** N.N. **Language:** English **Frequency:** every winter semester **Contents:** In the exercise sessions, lecture contents are expanded upon and their application is practiced.	**2,00 Weekly Contact Hours**

Examination Written examination / Duration of Examination: 90 minutes **Description:** By voluntarily handing in graded assignments (semesterbegleitende Studienleistungen) during the semester, points can be collected to improve the grade, which can be credited to the exam, provided that the exam is also passed without points from assignments. At the beginning of the course, it will be announced whether graded assignments are offered. If offered, the number, type, scope and processing time of the assignments as well as the number of achievable points per assignment and in the module examination will also be announced at this time. A grade of 1.0 can also be achieved without points from the assignments.	

Module VIS-Proj-B Bachelor Project Information Visualization *Bachelorprojekt Informationsvisualisierung*		6 ECTS / 180 h
(since SS24) Person responsible for module: Prof. Dr. Fabian Beck		
Contents: In the project, students explore and apply different state-of-the-art approaches of applied computer science as a practical exercise. For a given scenario, a basic interactive visualization application is to be developed in a group effort.		
Learning outcomes: Students learn to work independently on a practical problem and to coordinate this with group members. They design an interactive application that meets the requirements of a given scenario, while understanding the possibilities offered by visual and algorithmic methods. They implement a software system as a team, recognize the challenges of such collaboration, and jointly find solutions.		
Remark: The workload for this module typically is as follows: • Sessions and group meetings: 45h • Background research and reading: 15h • Implementation: 90h • Documentation and presentation: 30h		
prerequisites for the module: none		
Recommended prior knowledge: Basic programming skills; basic knowledge in visualization, human-computer-interaction, or machine learning and data science can be beneficial.		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Bachelorprojekt Informationsvisualisierung **Mode of Delivery:** **Lecturers:** Prof. Dr. Fabian Beck, N.N. **Language:** English/German **Frequency:** every winter semester **Contents:** See module description **Literature:** Further material and reading will be announced in the course.	**4,00 Weekly Contact Hours**

Examination	
Coursework Assignment and Colloquium / Duration of Coursework: 4 months	

Description: The language of the course and exam will be announced in the first session of the course.	

Module VIS-Proj-M Master Project Information Visualization *Masterprojekt Informationsvisualisierung*		6 ECTS / 180 h
(since SS24) Person responsible for module: Prof. Dr. Fabian Beck		
Contents: In the project, students explore and apply different state-of-the-art approaches of applied computer science as a practical exercise. For a given scenario, an advanced interactive visualization application is to be developed in a group effort.		
Learning outcomes: Students learn to work independently on a research-oriented problem and to coordinate this with group members. They design an interactive application that meets the requirements of a given scenario, while understanding the possibilities offered by visual and algorithmic methods. They implement a software system as a team, recognize the challenges of such collaboration, and jointly find solutions.		
Remark: The workload for this module typically is as follows: • Sessions and group meetings: 45h • Background research and reading: 15h • Implementation: 90h • Documentation and presentation: 30h		
prerequisites for the module: none		
Recommended prior knowledge: Advanced programming skills; basic knowledge in visualization, human-computer-interaction, or machine learning and data science can be beneficial.		**Admission requirements:** none
Frequency: 1	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Masterprojekt Informationsvisualisierung **Mode of Delivery:** **Lecturers:** Prof. Dr. Fabian Beck, N.N. **Language:** English/German **Frequency:** every summer semester **Contents:** See module description **Literature:** Further material and reading will be announced in the course.	**4,00 Weekly Contact Hours**

Examination	
Coursework Assignment and Colloquium / Duration of Coursework: 4 months	

prerequisites for module examination: Regular participation in the course **Description:** The language of the course and exam will be announced in the first session of the course.	

Module VIS-Sem-B Bachelor Seminar Information Visualization *Bachelorseminar Informationsvisualisierung*		3 ECTS / 90 h
(since SS22) Person responsible for module: Prof. Dr. Fabian Beck		
Contents: Das Seminar behandelt praktische Anwendungen von Visualisierungssystemen. Es werden deren Eigenschaften diskutiert und verglichen, sowie deren Implementierung untersucht. Alle Teilnehmenden bearbeiten individuell zugewiesene Themen, die unterschiedliche Facetten zu einem übergreifenden Seminarthema beitragen.		
Learning outcomes: Die Studierenden können ein vorgegebenes Thema der Angewandten Informatik selbstständig recherchieren. Sie lernen moderne Benutzerschnittstellen und Visualisierungssysteme zu bewerten und entwickeln ein vertieftes Verständnis des jeweiligen Themas, seiner Einsatz- und Anwendungsmöglichkeiten sowie seiner Grenzen. Sie verstehen und üben Methoden der professionellen Kommunikation in mündlicher und schriftlicher Form.		
Remark: Der Arbeitsaufwand für dieses Modul gliedert sich grob wie folgt: • Präsenzzeit: 20h • Recherche: 25h • Vorbereitung der Präsentation: 15h • Erstellung einer schriftlichen Ausarbeitung: 30h		
prerequisites for the module: keine		
Recommended prior knowledge: grundlegende Programmierkenntnisse		**Admission requirements:** keine
Frequency: every semester	**Recommended semester:** from 2.	**Minimal Duration of the Module:** 1 Semester

Module Units	
Bachelorseminar Informationsvisualisierung **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Fabian Beck, N.N. **Language:** English/German **Frequency:** every semester **Contents:** Siehe Modulbeschreibung **Literature:** Weiterführende Unterlagen werden in der Veranstaltung bekannt gegeben.	**2,00 Weekly Contact Hours**

Examination Coursework Assignment with presentation / Duration of Examination: 20 minutes	

Duration of Coursework: 4 months **prerequisites for module examination:** Regelmäßige Teilnahme an der Lehrveranstaltung **Description:** Die Bekanntgabe der Lehr- und Prüfungssprache erfolgt in der ersten Sitzung der Lehrveranstaltung.	

Module VIS-Sem-M Master Seminar Information Visualization *Masterseminar Informationsvisualisierung*			3 ECTS / 90 h
(since SS22) Person responsible for module: Prof. Dr. Fabian Beck			
Contents: The seminar investigates current trends in a subarea of visualization research. Based on an extensive literature review, different visualization approaches will be compared and evaluated. All participants work on individually assigned topics that contribute different facets to an overarching seminar topic.			
Learning outcomes: Students learn to independently research and find the latest research results regarding a given research topic in applied computer science. They discuss and evaluate state-of-the-art research results and develop a deep understanding of the individual topic, its potential use and application as well as limitations. They practice methods of scientific communication in oral and written form.			
Remark: The workload for this module typically is as follows: • Sessions: 20h • Literature search and reading: 25h • Preparation of presentation: 15h • Report writing: 30h			
prerequisites for the module: none			
Recommended prior knowledge: None required, but basic knowledge in visualization, human-computer-interaction, or machine learning and data science can be beneficial.			**Admission requirements:** none
Frequency: every semester	**Recommended semester:**		**Minimal Duration of the Module:** 1 Semester

Module Units	
Masterseminar Informationsvisualisierung **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Fabian Beck, N.N. **Language:** English/German **Frequency:** every semester **Contents:** See module description **Literature:** Further material and reading will be announced in the course.	**2,00 Weekly Contact Hours**

Examination Coursework Assignment with presentation / Duration of Examination: 30 minutes Duration of Coursework: 4 months	

prerequisites for module examination: Regular participation in the course **Description:** The language of the course and exam will be announced in the first session of the course.	

Module xAI-DL-M Deep Learning *Deep Learning*		6 ECTS / 180 h
(since WS24/25) Person responsible for module: Prof. Dr. Christian Ledig		
Contents: Deep Learning is a form of machine learning that learns hierarchical concepts and representations directly from data. Enabled by continuously growing dataset sizes, compute power and rapidly evolving open-source frameworks Deep Learning based AI systems continue to set the state of the art in many applications and industries. The course will provide an introduction to the most relevant techniques in the field of Deep Learning and a broad range of its applications.		
Learning outcomes: In this course students will learn/recap some fundamentals from mathematics and machine learning that are critical for the introduction of the concept of Deep Learning. Participants will learn about various foundational technical aspects including optimization and regularization strategies, cost functions and important network architectures such as Convolutional Networks. Students will further get an insight into more advanced concepts such as sequence modelling and generative modelling. Participants will further learn about representative architectures of important algorithm categories, e.g., classification, detection, segmentation, some of their concrete use cases and how to evaluate them. The lecture is accompanied by exercises and assignments that will help participants develop practical, hands-on experience. In those exercises students will learn how to implement and evaluate Deep Learning algorithms using Python and its respective commonly used libraries.		
Remark: The lecture is conducted in English. The workload of this module is expected to be roughly as follows: • Lecture: 22.5h (equals the 2 SWS) • Preparation of lectures and analysis of further sources: 30h (over the 15 weeks term) • Exercise classes accompanying lecture: 22.5h (equals the 2 SWS) • Work on the actual assignments: 75h (over the 15 weeks term) • Preparation for exam: 30h		
prerequisites for the module: none		
Recommended prior knowledge: Strongly recommended: Good working knowledge of programming (in particular Python), Mathematics for Machine Learning [xAI-MML] Further recommended (or similar): Bachelorproject Erklärbares Maschinelles Lernen [xAI-Proj-B], Lernende Systeme / Machine Learning [KogSys-ML-B], Einführung in die Künstliche Intelligenz / Introduction to AI [KogSys-KI-B], Algorithmen und Datenstrukturen [AI-AuD-B]		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Deep Learning **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Christian Ledig **Language:** English/German **Frequency:** every winter semester **Learning outcome:** c.f. module description **Contents:** The lecture will be held in English. The following is a selection of topics that will be addressed in the course • Relevant concepts in linear algebra, probability and information theory • Deep feedforward networks • Convolutional Neural Networks • Regularization, Batch Normalization • Optimization (Backpropagation, Stochastic Gradient Decent) and Cost Functions • Classification (binary, multiclass, multilabel) • Object Detection & Segmentation • Generative Modelling • Attention mechanisms & Transformer Networks • Evaluation of ML approaches **Literature:** • Ian Goodfellow, Yoshua Bengio, and Aaron Courville: Deep Learning, MIT Press, 2016 • Zhang, Lipton, et al.: Dive into Deep Learning (https://d2l.ai/) Further literature will be announced at the beginning of the course.	**2,00 Weekly Contact Hours**
2. Deep Learning **Mode of Delivery:** Practicals **Lecturers:** N.N. **Language:** English/German **Frequency:** every winter semester **Learning outcome:** see module description **Contents:** Further exploration of concepts discussed in the lecture, often accompanied by assigments and programming exercises implemented in Python and the corresponding machine/deep learning libraries. **Literature:** see lecture description	**2,00 Weekly Contact Hours**

Examination	
Written examination / Duration of Examination: 90 minutes **Description:**	

The content that is relevant for the exam consists of the content presented in the lecture and exercises/tutorials (including the assignments) as well as additional content of the discussed literature, which will be highlighted. Participants can collect bonus points by working on and solving the assignments discussed during the exercises/tutorials. Details regarding the number of assignments, the number of points per assignment, and the type of assignments will be announced in the lecture. If the points achieved in the exam are sufficient to pass the exam on its own, the bonus points (at most 20% of the maximum achievable points in the exam) will be added to the points achieved in the exam. The grade 1.0 can be achieved without the bonus points.	

Module xAI-MML-B Mathematics for Machine Learning *Mathematics for Machine Learning*		6 ECTS / 180 h
(since SS25) Person responsible for module: Prof. Dr. Christian Ledig		
Contents: The course aims to establish a common mathematical foundation for the further study of advanced machine learning techniques. The content is selected specifically to be most relevant for students interested in machine learning problems and covers a broad range of concepts from, e.g., linear algebra, vector calculus, probability theory, statistics, and optimization.		
Learning outcomes: In this course students will learn fundamental mathematical concepts that are important prerequisites for the deeper understanding of the field of machine learning. The overarching goal of this course is to build a mathematical foundation by selectively covering the most essential mathematical concepts form a broad range of mathematical disciplines. Dependent on previous background, students will get the chance to learn critical ML-relevant mathematics for the first time or consolidate concepts that have been partially covered in their previous curriculum. The lecture is accompanied by exercises and assignments that will help participants develop both theoretical and practical experience. In those exercises students will get the opportunity to learn how to apply and prove theoretical concepts as well as implement some concrete algorithms in Python and its respective commonly used libraries. Course is also open to MSc students with the goal of building / consolidating their mathematical foundation with a focus on machine learning applications.		
Remark: The lecture is conducted in English. The workload of this module is expected to be roughly as follows: • Lecture: 22.5h (equals the 2 SWS) • Preparation of lectures and analysis of further sources: 30h (over the 15 weeks term) • Exercise classes accompanying lecture: 22.5h (equals the 2 SWS) • Work on the actual assignments: 75h (over the 15 weeks term) • Preparation for exam: 30h		
prerequisites for the module: none		
Recommended prior knowledge: No specific prior knowledge is required.		**Admission requirements:** none
Frequency: every summer semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
1. Mathematics for Machine Learning **Mode of Delivery:** Lectures **Lecturers:** Prof. Dr. Christian Ledig **Language:** English/German **Frequency:** every summer semester **Learning outcome:**	**2,00 Weekly Contact Hours**

<table>
<tr><td>c.f. module description

Contents:
The lecture will be held in English. The following is a selection of topics that will be addressed in the course

• Linear Algebra (e.g., vector spaces, span, basis, rank)
• Analytic Geometry (e.g., norms, inner product, projections)
• Matrix decompositions (e.g., Eigenvectors, SVD)
• Vector calculus (e.g., derivatives, Taylor series)
• Information Theory (e.g., entropy, KL divergence)
• Probability theory and distributions
• Statistics (e.g., estimators, tests)
• Optimization (e.g., gradient based)
• Machine Learning Problems (e.g., Density estimation, Dimensionality Reduction)

Literature:
• Marc. Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong: Mathematics for Machine Learning, Cambridge University Press, 2020

Further literature will be announced at the beginning of the course.</td><td></td></tr>
<tr><td>2. Mathematics for Machine Learning
Mode of Delivery: Practicals
Lecturers: N.N.
Language: English/German
Frequency: every summer semester

Learning outcome:
see module description

Contents:
Further exploration of concepts discussed in the lecture by specific assigments and some programming exercises implemented predominantly in Python.

Literature:
see lecture description</td><td>2,00 Weekly Contact Hours</td></tr>
</table>

<table>
<tr><td>Examination
Written examination / Duration of Examination: 90 hours
Description:
The content that is relevant for the exam consists of the content presented in the lecture and exercises/tutorials (including the assignments) as well as additional content of the discussed literature, which will be highlighted.</td><td></td></tr>
</table>

<table>
<tr><td colspan="2">Module xAI-Proj-B Bachelor Project Explainable Machine Learning
Bachelorprojekt Erklärbares Maschinelles Lernen</td><td>6 ECTS / 180 h</td></tr>
<tr><td colspan="3">(since SS24)
Person responsible for module: Prof. Dr. Christian Ledig</td></tr>
<tr><td colspan="3">Contents:
The course provides to students the opportunity to work in small groups (ca. 2-3) in a hands-on fashion on selected state-of-the-art methodologies that are critical when bringing robust algorithms into practice. The project builds on and adds practical experience to the knowledge from corresponding lectures and exercises in the area of machine learning.</td></tr>
<tr><td colspan="3">Learning outcomes:
Students will familiarize themselves with a specific aspect of robust, explainable machine learning systems. Participants will learn to tackle a research-oriented question or problem independently, with little guidance. This will often involve the critical tasks: literature review, preparation and examination of datasets, implementation and comparison of prototypes, quantitative and qualitative evaluation of approaches. Within small groups, participants will learn to coordinate their project in a team and get comfortable with best practices of software development (e.g., testing, VCS).
Documentation and presentation of the project will help to develop both oral (presentation) and written (technical project report) communication skills in a scientific environment. In comparison to the Bachelor Project this Master Project is more ambitious in terms of complexity of selected topics as well as expectations with respect to deliverables and presentations.</td></tr>
<tr><td colspan="3">Remark:
The workload of this module is expected to be roughly as follows:
• Attendance of project meetings / presentation: 35h
• Literature review and familiarization with topic (individual and within the team): 20h
• Implementation of selected algorithm / methodology: 70h
• Preparation of presentation: 15h
• Written documentation and report: 40h</td></tr>
<tr><td colspan="3">prerequisites for the module:
none</td></tr>
<tr><td colspan="2">Recommended prior knowledge:
Recommended completion of modules "Lernende System / Machine Learning" or "Einführung in die KI / Introduction into AI.</td><td>Admission requirements:
none</td></tr>
<tr><td>Frequency: every summer semester</td><td>Recommended semester:</td><td>Minimal Duration of the Module:
1 Semester</td></tr>
</table>

<table>
<tr><td colspan="2">Module Units</td></tr>
<tr><td>Bachelorprojekt Erklärbares Maschinelles Lernen
Mode of Delivery:
Lecturers: Prof. Dr. Christian Ledig, N.N.
Language: English/German
Frequency: every summer semester
Contents:
see module description</td><td>4,00 Weekly Contact Hours</td></tr>
</table>

Literature: Will be announced at the beginning of the course.	

Examination Coursework Assignment and Colloquium / Duration of Examination: 20 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regular attendance of project and other presentations. **Description:** The default language of the course is English.	

Module xAI-Proj-M Master Project Explainable Machine Learning *Masterprojekt Erklärbares Maschinelles Lernen*	6 ECTS / 180 h

(since SS24)
Person responsible for module: Prof. Dr. Christian Ledig

Contents:
The course provides to students the opportunity to work in small groups (ca. 2-3) in a hands-on fashion on selected state-of-the-art methodologies that are critical when bringing robust algorithms into practice. The project builds on and adds practical experience to the knowledge from corresponding lectures and exercises in the area of machine learning.

Learning outcomes:
Students will familiarize themselves with a specific aspect of robust, explainable machine learning systems. Participants will learn to tackle a research-oriented question or problem independently, with little guidance. This will often involve the critical tasks: literature review, preparation and examination of datasets, implementation and comparison of prototypes, quantitative and qualitative evaluation of approaches. Within small groups, participants will learn to coordinate their project in a team and get comfortable with best practices of software development (e.g., testing, VCS).
Documentation and presentation of the project will help to develop both oral (presentation) and written (technical project report) communication skills in a scientific environment. In comparison to the Bachelor Project this Master Project is more ambitious in terms of complexity of selected topics as well as expectations with respect to deliverables and presentations.

Remark:
The workload of this module is expected to be roughly as follows:
• Attendance of project meetings / presentation: 35h
• Literature review and familiarization with topic (individual and within the team): 20h
• Implementation of selected algorithm / methodology: 70h
• Preparation of presentation: 15h
• Written documentation and report: 40h

prerequisites for the module:
none

Recommended prior knowledge: Recommended completion of modules "Lernende System / Machine Learning", "Einführung in die KI / Introduction into AI" and „Deep Learning“.		**Admission requirements:** none
Frequency: every winter semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
xAI-Proj-M: Masterprojekt Erklärbares Maschinelles Lernen **Mode of Delivery:** **Lecturers:** Prof. Dr. Christian Ledig, N.N. **Language:** English/German **Frequency:** every winter semester **Contents:**	**4,00 Weekly Contact Hours**

see module description **Literature:** Will be announced at the beginning of the course.	

Examination Coursework Assignment and Colloquium / Duration of Examination: 20 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regular attendance of project and other presentations. **Description:** The default language of the course is English.	

Module xAI-Sem-B1 Bachelor Seminar Explainable Machine Learning *Bachelorseminar Erklärbares Maschinelles Lernen*		3 ECTS / 90 h
(since SS23) Person responsible for module: Prof. Dr. Christian Ledig		
Contents: Machine Learning holds great promise to transform a variety of industries including healthcare. However, there are key challenges when translating AI technology reliably into practice. In this seminar students will learn about a selected subarea of machine learning often in the context of a particular application. The seminar will enable students to apply knowledge from corresponding lectures and exercises and independently explore a particular research-oriented topic based on published literature. The seminar focuses on a wide spectrum of aspects not limited to pure technical questions.		
Learning outcomes: Students will learn about the potential as well as current challenges when translating AI systems into practice. Participants will learn to independently research their specific topic by deep diving into and structuring published literature. Within the seminar students learn to present and communicate state-of-the-art research results in both oral (presentation) and written form (technical report). Seminar participants will further learn about and critically discuss scientific questions with their peers. In comparison to the Master Seminar this Bachelor Seminar is more moderate in terms of complexity of selected topics as well as expectations with respect to delivered reports and presentations.		
Remark: This seminar is generally conducted in English. The workload of this module is expected to be roughly as follows: • Attendance of seminar / presentation: 20h • Literature review and familiarization with topic: 25h • Preparation of presentation: 15h • Written report: 30h		
prerequisites for the module: none		
Recommended prior knowledge: Recommended completion of modules "Lernende System / Machine Learning" or "Einführung in die KI / Introduction into AI.		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Bachelorseminar Erklärbares Maschinelles Lernen **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Christian Ledig **Language:** English/German **Frequency:** every semester **Contents:** see module description **Literature:**	**2,00 Weekly Contact Hours**

will be announced at the beginning of the course.	

Examination Coursework Assignment with presentation / Duration of Examination: 30 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regular attendance of seminar and other presentations **Description:** The seminar will be held in English including the report and presentations.	

Module xAI-Sem-M1 Master Seminar Explainable Machine Learning *Masterseminar Erklärbares Maschinelles Lernen*		3 ECTS / 90 h
(since SS22) Person responsible for module: Prof. Dr. Christian Ledig		
Contents: Machine Learning holds great promise to transform a variety of industries including healthcare. However, there are key challenges when translating AI technology reliably into practice. In this seminar students will learn about a selected subarea of machine learning often in the context of a particular application. The seminar will enable students to apply knowledge from corresponding lectures and exercises and independently explore a particular research-oriented topic based on published literature. The seminar focuses on a wide spectrum of aspects not limited to pure technical questions.		
Learning outcomes: Students will learn about the potential as well as current challenges when translating AI systems into practice. Participants will learn to independently research their specific topic by deep diving into and structuring published literature. Within the seminar students learn to present and communicate state-of-the-art research results in both oral (presentation) and written form (technical report). Seminar participants will further learn about and critically discuss scientific questions with their peers. In comparison to the Bachelor Seminar this Master Seminar is more ambitious in terms of complexity of selected topics as well as expectations with respect to delivered reports and presentations.		
Remark: This seminar is generally conducted in English. The workload of this module is expected to be roughly as follows: • Attendance of seminar / presentation: 20h • Literature review and familiarization with topic: 25h • Preparation of presentation: 15h • Written report: 30h		
prerequisites for the module: none		
Recommended prior knowledge: Recommended completion of module "Lernende System / Machine Learning" or "Einführung in die KI / Introduction into AI" or „Deep Learning“		**Admission requirements:** none
Frequency: every semester	**Recommended semester:**	**Minimal Duration of the Module:** 1 Semester

Module Units	
Master Seminar Explainable Machine Learning **Mode of Delivery:** Seminar **Lecturers:** Prof. Dr. Christian Ledig **Language:** English/German **Frequency:** every semester **Contents:** see module description	**2,00 Weekly Contact Hours**

Literature: Will be announced at the beginning of the course.	

Examination Coursework Assignment with presentation / Duration of Examination: 30 minutes Duration of Coursework: 4 months **prerequisites for module examination:** Regular attendance of seminar and other presentations. **Description:** The seminar will be held in English including the report and presentations.	

ID	Module	Semester	ECTS	Weekly Contact Hours	Examination
	International studies taught in English (on demand)				
	Find all courses taught in English (on demand) below. Please note: Lectureres will usally ask in the first session whether it should be held in German or English. It is possible, however, they will conduct their session in German. Please don't be afraid to demand continuing in English.				
	Subject Group: Applied Computer Science				
	Subject: AI Systems Engineering				
AISE-ETH	Ethics and Epistemology of AI	every summer semester(1)	6	2 Lectures 2 Practicals	Portfolio
AISE-FTAIP-B	Frontier Topics in AI and Philosophy	no value(1)	6	2 Lectures 2 Practicals	Written examination 90 minutes
AISE-PLM-V	Computational Metaphysics -- Mechanizing Principia Logico-Metaphysica	annually(1)	3	2	Oral examination 30 minutes
AISE-Proj-B	Bachelorprojekt KI-Systementwicklung	every winter semester(1)	6	4	Coursework Assignment and Colloquium (project report, a review and a presentation (all in English)) 4 months
AISE-ProjPrak-UR	Universal Reasoning (in Philosophy, Mathematics and Computer Science)	every winter semester(1)	15	6	Sonstiges
AISE-Sem-M	Masterseminar zu KI-Systementwicklung (Oberseminar)	every semester(1)	3	2 Seminar	Internship report 3 months 30 minutes
AISE-SemCP-B	Bachelorseminar Computational Philosophy	every winter semester(1)	3	2 Seminar	Coursework Assignment with presentation 3 months 30 minutes
AISE-UL	Universal Logic & Universal Reasoning	every winter semester(1)	6	2 Lectures and Practicals 2 Practicals	Written examination (AISE-UL: Universal Logic & Universal

					Reasoning (Universelle Logik & Universelles Schließen))
	Subject: Cognitive Systems				
KogSys-Proj-B	Bachelor Project Cognitive Systems	every summer semester	6	4	Coursework Assignment and Colloquium 4 months 20 minutes
KogSys-Sem-B	Bachelor Seminar Cognitive Systems	every winter semester	3	2 Seminar	Coursework Assignment with presentation 4 months 30 minutes
	Subject: Computer Graphics and its Foundations				
CG-ProjCGA-B	Project Computer Graphics	every summer semester(1)	6	4	Coursework Assignment and Colloquium
CG-ProjCGA-M	Project Computer Graphics	every summer semester(1)	6	4	Coursework Assignment and Colloquium
CG-ProjVRAR-B	Project Virtual Reality / Augmented Reality	every winter semester(1)	6	4	Coursework Assignment and Colloquium 30 minutes
CG-ProjVRAR-M	Project Virtual Reality / Augmented Reality	every winter semester(1)	6	4	Coursework Assignment and Colloquium 30 minutes
CG-SemCGA-B	Seminar Computer Graphics and Animation	every summer semester(1)	3	2 Seminar	Internship report 2 months 20 minutes
CG-SemVRAR-B	Seminar Virtual Reality / Augmented Reality	every winter semester(1)	3	2 Seminar	Internship report 2 months 20 minutes

CG-VRAR-M	Virtual Reality / Augmented Reality	every summer semester	6	2 Lectures 2 Practicals	Written examination
	Subject: Explainable Machine Learning				
xAI-DL-M	Deep Learning	every winter semester(1)	6	2 Lectures 2 Practicals	Written examination 90 minutes
xAI-MML-B	Mathematics for Machine Learning	every summer semester(1)	6	2 Lectures 2 Practicals	Written examination 90 hours
xAI-Proj-B	Bachelor Project Explainable Machine Learning	every summer semester(1)	6	4	Coursework Assignment and Colloquium 4 months 20 minutes
xAI-Proj-M	Master Project Explainable Machine Learning	every winter semester(1)	6	4	Coursework Assignment and Colloquium 4 months 20 minutes
xAI-Sem-B1	Bachelor Seminar Explainable Machine Learning	every semester(1)	3	2 Seminar	Coursework Assignment with presentation 4 months 30 minutes
xAI-Sem-M1	Master Seminar Explainable Machine Learning	every semester(1)	3	2 Seminar	Coursework Assignment with presentation 4 months 30 minutes
	Subject: Fundamentals of Natural Language Processing				
NLProc-ANLP-M	Applied Natural Language Processing	every semester(1)	6	2 Lectures and Practicals 2	Internship report
NLProc-ILT-M	Impact of Language Technology	every winter semester(1)	6	4 Lectures and Practicals	Written examination 60 minutes

NLProc-PGM4NLP-M	Probabilistic Graphical Models for Natural Language Processing	every winter semester(1)	6	4 Lectures and Practicals	Written examination 60 minutes
NLProc-Sem1-M	Master Seminar Natural Language Processing 1	every semester(1)	3	2 Seminar 2 Seminar 2 Seminar 0 Seminar	Internship report
NLProc-Sem2-M	Master Seminar Natural Language Processing 2	every semester(1)	3	2 Seminar 2 Seminar 2 Seminar 0 Seminar	Internship report
	Subject: Human-Computer Interaction				
HCI-DFM-M	Design and Research Methods of Human-Computer Interaction	every summer semester	6	2 Lectures 2 Practicals	Oral examination Written examination 90 minutes
HCI-DISTP-B	Design of Interactive Systems: Theory and Practice	every summer semester(1)	6	1 Lectures and Practicals 1 Practicals	Colloquium 30 minutes Colloquium 30 minutes
HCI-IS-B	Interactive Systems	every winter semester	6	2 Lectures 2 Practicals	Written examination 90 minutes Oral examination
HCI-KS-B	Cooperative Systems	every summer semester	6	2 Lectures 2 Practicals	Oral examination Written examination 90 minutes
HCI-MCI-M	Human-Computer Interaction	every winter semester	6	2 Lectures 2 Practicals	Oral examination Written examination 90 minutes
HCI-Proj-B	Project Human-Computer Interaction	every winter semester	6	4	Coursework Assignment and Colloquium 4 months

					30 minutes
HCI-Proj-M	Project Human-Computer Interaction	every summer semester	6	4	Coursework Assignment and Colloquium 4 months 30 minutes
HCI-Proj1-M	Research-Project Human-Computer Interaction	every summer semester(WS 2016/2017)	15	6	Coursework Assignment and Colloquium 4 months 30 minutes
HCI-Proj2-M	Research-Project Human-Computer Interaction	every winter semester(WS 2016/2017)	15	6	Coursework Assignment and Colloquium 4 months 30 minutes
HCI-Prop-M	Propaedeutic: Human-Computer-Interaction	every winter semester(1)	3	3	Internship report 4 months 30 minutes
HCI-Sem-B	Bachelor-Seminar Human-Computer Interaction	every summer semester	3	2 Seminar	Internship report 4 months 30 minutes
HCI-Sem-HCC-M	Master-Seminar Human-Centred Computing	every summer semester	3	2 Seminar	Internship report 4 months 30 minutes
HCI-Sem-M	Master-Seminar Human-Computer Interaction	every winter semester	3	2 Seminar	Internship report 4 months 30 minutes
HCI-US-B	Ubiquitous Systems	every winter semester	6	2 Lectures 2 Practicals	Oral examination Written examination 90 minutes
HCI-Usab-M	Usability in Practice	every summer semester	6	4 Practicals	Coursework Assignment and Colloquium 4 months

					30 minutes
	Subject: Information Visualization				
VIS-IVVA-M	Advanced Information Visualization and Visual Analytics	every winter semester(1)	6	2 Lectures 2 Practicals	Written examination 90 minutes
VIS-Proj-B	Bachelor Project Information Visualization	every winter semester(1)	6	4	Coursework Assignment and Colloquium 4 months
VIS-Proj-M	Master Project Information Visualization	no value(1)	6	4	Coursework Assignment and Colloquium 4 months
VIS-Sem-B	Bachelor Seminar Information Visualization	every semester(1)	3	2 Seminar	Coursework Assignment with presentation 4 months 20 minutes
VIS-Sem-M	Master Seminar Information Visualization	every semester(1)	3	2 Seminar	Coursework Assignment with presentation 4 months 30 minutes
	Subject: Multimodal Intelligent Interaction				
MII-ProjCR-B	Bachelor Project Cognitive Robotics	every summer semester(1)	6	4 Seminar	Coursework Assignment and Colloquium 4 months 20 minutes
MII-ProjCR-M	Master Project Cognitive Robotics	every summer semester(1)	6	4 Seminar	Coursework Assignment and Colloquium 4 months 20 minutes
MII-SemHRI-B	Bachelor Seminar Human-Robot Interaction	every winter semester(1)	3	2 Seminar	Internship report 4 months 20 minutes

MII-SemHRI-M	Master Seminar Human-Robot Interaction	every winter semester(1)	3	2 Seminar	Internship report 4 months 20 minutes
	Subject: Natural Language Generation and Dialogue Systems				
DS-ConvAI-M	Advanced Dialogue Systems and Conversational AI	every summer semester(1)	6	2 Lectures 2 Practicals	Oral examination 30 minutes
DS-Proj-M	Project Dialogue systems	every semester(1)	6	4	Coursework Assignment and Colloquium 45 minutes
DS-Sem-M	Master Seminar Conversational AI	every semester(1)	3	2 Seminar	Coursework Assignment with presentation 45 minutes
	Subject Group: Computer Science				
Inf-DM-B	Discrete Modeling	every winter semester(1)	9	6 Lectures and Practicals	Written examination
	Subject: Algorithms and Complexity Theory				
AlgoK-AK-B	algorithms and complexity	every summer semester(1)	6	2 Lectures and Practicals	Oral examination
AlgoK-Sem-B	Bachelor Seminar Algorithms and Complexity Theory	winter and summer semester, on demand(1)	3	2 Seminar	Internship report 4 months 30 minutes
AlgoK-Sem-M	Master Seminar Algorithms and Complexity Theory	winter and summer semester, on demand(1)	3	2 Seminar	Internship report 4 months 30 minutes
AlgoK-TAG	Baumzerlegungen, Algorithmen und Spiele		6	4 Lectures and Practicals	Sonstiges

		every winter semester(1)			90 minutes
	Subject: Data Engineering				
DT-CPP-B	Introduction into Systems Programming in C++	every winter semester(1)	6	4 Lectures and Practicals	Portfolio 4 months 30 minutes
DT-CPP-M	Advanced Systems Programming in C++ (Master)	every winter semester(1)	6	4 Lectures and Practicals	Portfolio 4 months 30 minutes
DT-DB4MLKD-B	Modern Database Systems for Machine Learning and Knowledge Discovery	winter and summer semester, on demand(1)	3	3 Seminar	Internship report 14 days 30 minutes
DT-DBCPU-M	Database Systems for modern CPU	every summer semester(1)	6	4 Lectures and Practicals	Written examination 20 minutes
DT-Proj-B	Bachelor Project: Data Engineering	every semester(1)	6	4	Colloquium, Coursework Assignment 3 months 30 minutes
DT-Proj-M	Project: Data Engineering	every semester(1)	6	4	Colloquium, Coursework Assignment 3 months 30 minutes
	Subject: Distributed Systems				
DSG-IDistrSys-B	Introduction to Distributed Systems	every summer semester(2025)	6	2 Lectures 2 Practicals	Coursework Assignment and Colloquium 3 months 10 minutes
	Subject: Foundations of Computer Science				

GdI-CSNL-M	Computational Semantics of Natural Language	every summer semester(1)	6	4	Portfolio 80 minutes
GdI-FPRS-M	Functional Programming of Reactive Systems	every summer semester	6	2 Lectures 2 Practicals	Written examination 90 minutes Oral examination 30 minutes
GdI-GTI-B	Machines and Languages	every summer semester	6	2 Lectures 2 Practicals	Written examination 90 minutes
GdI-IFP-M	Introduction to Functional Programming	every winter semester	6	2 Lectures 2 Practicals	Written examination 90 minutes
GdI-Proj-B	Foundations of Computing Project	every semester	6	4	Coursework Assignment and Colloquium 4 months 20 minutes
GdI-Proj-M	Master's Project Theoretical Foundations of Computing	every semester	6	4	Coursework Assignment and Colloquium 4 months 20 minutes
GdI-Sem-B	Seminar Foundations of Computing	winter and summer semester, on demand	3	2 Seminar	Coursework Assignment with presentation 4 months 30 minutes
GdI-Sem-M	Master's Seminar Theoretical Computer Science	winter or summer semester, on demand	3	2 Seminar	Coursework Assignment with presentation 4 months 30 minutes
	Subject: Mobile Software Systems/Mobility				
MOBI-ADM-M	Advanced Data Management		6	2 Lectures	Written examination

		every summer semester(1)		2 Practicals	75 minutes
MOBI-DSC-M	Data Streams and Complex Event Processing	every winter semester(1)	6	2 Lectures 2 Practicals	Oral examination 15 minutes Written examination 60 minutes
MOBI-PRS-M	Master Project Mobile Software Systems (SoSySc)	every summer semester(1)	9	6	Coursework Assignment and Colloquium
MOBI-Proj-B	Bachelor Project Mobile Software Systems	every semester(1)	6	4	Coursework Assignment and Colloquium
MOBI-Proj-M	Master Project Mobile Software Systems	every winter semester(1)	6	4	Coursework Assignment and Colloquium
MOBI-SEM-B	Bachelor-Seminar Mobile Software Systems	every winter semester(1)	3	2 Seminar	Coursework Assignment with presentation
MOBI-SEM-M	Master-Seminar Mobile Software Systems	every winter semester(1)	3	2 Seminar	Coursework Assignment with presentation
	Subject: Privacy and Security in Information Systems				
PSI-AdvaSP-M	Advanced Security and Privacy	every summer semester(1)	6	2 Lectures 2 Practicals	Written examination 110 minutes
PSI-DiffPriv-M	Introduction to Differential Privacy	every winter semester(1)	6	4 Lectures and Practicals	90 minutes
PSI-EDS-B	Ethics for the Digital Society	every winter semester	3	2 Lectures	Written examination 80 minutes
PSI-IntroSP-B	Introduction to Security and Privacy	every winter semester(1)	6	2 Lectures 2 Practicals	90 minutes Written examination 120 minutes

PSI-ProjectCAD-M	Project Complex Attacks and Defenses	every semester(1)	9	6	Coursework Assignment and Colloquium 3 months 30 minutes
PSI-ProjectPAD	Project Practical Attacks and Defenses	every semester(1)	6	4	Coursework Assignment and Colloquium 3 months 30 minutes
PSI-ProjectSP-M	Project Security and Privacy	every semester(1)	6	6	Coursework Assignment and Colloquium 3 months 30 minutes
PSI-SSSProject-B	Software Systems Science Project: Security and Privacy	every semester(1)	12	8	Coursework Assignment and Colloquium 3 months 30 minutes
PSI-Sem-B	Seminar Security and Privacy Foundations	every semester(1)	3	2 Seminar	Internship report 2 months 30 minutes
PSI-Sem-M	Seminar Research Topics in Security and Privacy	every semester(1)	3	2 Seminar	Internship report 2 months 30 minutes
	Subject: Software Technologies				
SWT-ASV-M	Applied Software Verification	every summer semester	6	2 Lectures 2 Practicals	Coursework Assignment and Colloquium 3 weeks 20 minutes
SWT-FPS-B	Foundations of Program Semantics	every winter semester	6	4 Lectures 2 Practicals	Coursework Assignment and Colloquium 3 weeks

					20 minutes
SWT-FSE-B	Foundations of Software Engineering	every summer semester	6	3 Lectures 3 Practicals	Written examination 120 minutes
SWT-PR1-M	Masters Project in Software Engineering and Programming Languages	every winter semester	6	4	Coursework Assignment and Colloquium (schriftliche Hausarbeit mit Kolloquium) 12 weeks 20 minutes
SWT-SEM-B	Seminar in Software Engineering and Programming Languages (Bachelor)	every summer semester	3	2 Seminar	Internship report 8 weeks 40 minutes
SWT-SEM-M	Seminar in Software Engineering and Programming Languages (Master)	every summer semester	3	2 Seminar	Internship report 8 weeks 40 minutes
SWT-SWL-B	Software Engineering Lab	every winter semester	6	4	Coursework Assignment and Colloquium (schriftliche Hausarbeit mit Kolloquium) 2 weeks 45 minutes
	Subject: Systems Programming				
SYSNAP-OSE-M	Operating Systems Engineering	every summer semester(1)	6	2 Lectures 2	Coursework Assignment and Colloquium 3 months 30 minutes
SYSNAP-Project-B	Project Systems Programming	every semester(1)	6	4	Coursework Assignment and Colloquium 3 months 30 minutes

SYSNAP-Project-M	Project Systems Programming	every semester(1)	6	4	Coursework Assignment and Colloquium 3 months 30 minutes
SYSNAP-SEM-B	Seminar System Software	every semester(1)	3	2 Seminar	Internship report 4 months 30 minutes
SYSNAP-SEM-M	Seminar System Software	every semester(1)	3	2 Seminar	Internship report 4 months 30 minutes
SYSNAP-Virt-M	Virtualization	every winter semester(1)	6	2 Lectures 2	Coursework Assignment and Colloquium 3 months 30 minutes
	Subject Group: Information Systems				
	Subject: AI Engineering in Companies				
AIC-HYIN-M	Hybrid Intelligence	every summer semester(1)	6	4 Lectures and Practicals	Coursework Assignment and Colloquium 3 months 60 minutes
AIC-SPRO-M	Research Project: Digital Society and AI-based Systems	every summer semester(1)	6	4	Coursework Assignment and Colloquium 3 months 60 minutes
AIC-WPRO-B	Practical Project: Human AI Collaboration	every winter semester(1)	6	4	Coursework Assignment and Colloquium 3 months 60 minutes
	Subject: Energy Efficient Systems				
EESYS-ADAML-M	Applied Data Analytics and Machine Learning in R		6	2 Lectures	Written examination

		every winter semester		2 Practicals	90 minutes
EESYS-BIA-M	Business Intelligence & Analytics	every winter semester	6	2 Lectures 2 Practicals	Written examination 90 minutes
EESYS-DDS-M	Data-driven Decision Support	every summer semester(1)	6	2 Lectures 2 Practicals	Written examination 90 minutes
EESYS-ES-M	Energy Efficient Systems	every summer semester	6	2 Lectures 2 Practicals	Written examination 90 minutes
EESYS-P-DINU-M	Project Digital Nudges for Behavior Change in Enterprise Information Systems	every summer semester(1)	6	4	Colloquium, Coursework Assignment 4 months 20 minutes
	Subject: Information Systems Management				
ISM-DSI-M	Global Collaboration and Digital Social Innovation	every winter semester(1)	6	0	Coursework Assignment with presentation (Global Collaboration and Digital Social Innovation)
	Subject: Information Systems and Services				
ISDL-ISS2-M	Optimization of IT-Reliant Processes	every summer semester	6	2 Lectures 2 Practicals	Written examination 90 minutes
	Subject: Platform economics				
ISPL-DIGB-B	Digital Business	every winter semester	6	2 Lectures 2 Practicals	Written examination 90 minutes
ISPL-DPIS-M	Digital Platforms in Industries and Society	every winter semester(1)	6	2 Lectures 2 Practicals	Written examination 90 minutes
ISPL-FIISM-B	Fundamentals of International IS Management		6	2 Lectures 2 Practicals	Written examination 90 minutes

		every summer semester(1)			
ISPL-MASI-B	Supplier relationships and mergers & acquisitions in the software industry	every winter semester	3	2	Written examination 90 minutes
ISPL-MDP-M	Managing Digital Platforms	every summer semester(1)	6	2 Lectures 2 Practicals	Written examination 90 minutes
	Subject: Social Networks				
SNA-OSN-M	Project Online Social Networks	every winter semester	6	4 Practicals	Coursework Assignment and Colloquium 4 months 30 minutes

ID	Module	Semester	ECTS	Weekly Contact Hours	Examination
	Course language German, exams in English on demand, course material may be available in English				
	Find all courses taught in German with course material available and exam held in English on demand below. Please notify the lecturer you need the course material/exam in English!				
	Subject Group: Applied Computer Science				
	Subject: Cognitive Systems				
KogSys-KI-B	Introduction to Artificial Intelligence	every summer semester(1)	6	2 Lectures 2 Practicals	105 minutes
	Subject Group: Computer Science				
	Subject: Foundations of Computer Science				
GdI-MTL-B	Modal and Temporal Logic	every winter semester	6	4 Lectures and Practicals	Oral examination
	Subject Group: Information Systems				
	Subject: Digital Health				
ISHANDS-Change-M	Digital Change Management	every summer semester	6	2 Lectures 2 Practicals	Written examination 90 minutes
ISHANDS-Health-M	Digital Health	every summer semester	6	2 Lectures 2 Practicals	Written examination 90 minutes
	Subject: Energy Efficient Systems				
	Subject: Industrial Information Systems				
IIS-Sem-B	Bachelor Seminar Industrial Information Systems	every winter semester	3	2 Introductory seminar	Coursework Assignment with presentation 3 months 30 minutes

IIS-Sem-M	Master Seminar Industrial Information Systems	every winter semester	3	2 Introductory seminar	Coursework Assignment with presentation 3 months 30 minutes
	Subject: Information Systems Management				
ISM-IOM-M	International Outsourcing Management	every winter semester	6	4	Written examination 90 minutes
	Subject: Information Systems and Services				
ISDL-DEXP-B	Digital Experimentation	every winter semester	6	2 Lectures and Practicals	Written examination 90 minutes
ISDL-ISS3-M	IT Business Value	every summer semester	6	2 Lectures 2 Practicals	Written examination 90 minutes
	Subject: Social Networks				
SNA-ASN-M	Social Network Analysis	every winter semester	6	2 Lectures 2 Practicals	Written examination 90 minutes
SNA-NET-M	Network Theory	every summer semester	6	2 Lectures 2 Practicals	Written examination 90 minutes
SNA-WIM-B	Knowledge- and Informationmanagement	every summer semester	6	2 Lectures 2 Practicals	Written examination 90 minutes