

Modulhandbuch

Automation & IT PO 3

Master of Engineering

Wintersemester 2026

Fakultät für Informatik und Ingenieurwissenschaften

12. Oktober 2026

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0.1 Program Description

Digital systems and tools are pivotal across industrial domains, revolutionizing efficiency, productivity, and innovation. System automation and application of data and information technologies are increasingly important for industrial processes.

System automation, robotics, the incorporation of industrial communication and IoT, data engineering and the application of Machine Learning and AI are crucial for enabling interconnected systems to operate as cohesive units, facilitating seamless data exchange and smart industrial processes. Sustainable energy systems are significantly enhanced by digital tools. Control engineering, closely tied to these efforts, ensures precise and efficient system behavior, driving innovation in managing energy supply and driving manufacturing processes. This adaptability is supported by optimization and numerical methods, which equip engineers with the skills to address complex system challenges.

In all industrial areas, IT security is paramount, protecting the integrity and continuity of interconnected industrial ecosystems from potential cyber threats. Data management, supported by robust database systems, ensures the accessibility and reliability of critical information, aiding analytics and informed decision-making across sectors.

In summary, modern digital tools and methodologies, underpinned by expertise in programming and optimization, are critical components that drive smarter, more responsive, and sustainable industrial operations. As technologies advance, their importance in fostering innovation and competitiveness within the industrial sector will only grow, underscoring the comprehensive knowledge imparted by these integrated modules.

It requires engineers who have internalized engineering thinking and action and understand their respective engineering domain. On the other hand, they must be proficient in handling, designing and applying modern digital information technologies and data infrastructures. Therefore, they form an important interface position between engineering and IT, enabling the effective application of new tools in their respective industrial environments.

From a more holistic perspective, it can be observed that the scientific disciplines of computer science and automation technology are merging into a unified field of knowledge in a large area of overlap. Engineers in automation technology will need to engage more deeply with information technology and computer science. For computer scientists, automation technology represents a diverse and forward-looking field of work. New developments, such as Ubiquitous Computing and Artificial Intelligence (AI), are creating promising new fields of work for both engineers and computer scientists.

The Master's program in Automation & IT aims to expand the specialist knowledge and methodological skills of students in the fields of automation technology and information technology, both in depth and breadth. These fields are applied in different industrial domains that are also taught in this Master's program.

Furthermore, the Master's program aims to further develop the abilities to structure, process, and make decisions on complex issues. Analytical thinking, as a prerequisite for an engineering approach, is particularly encouraged, as well as responsible action in technical projects. Starting with the current state of technology as a baseline, students are thus uniquely positioned to keep pace with rapidly advancing technological development. Additionally, they are qualified for activities in responsible positions in the fields of research, development, production, project planning, and management, as well as for pursuing subsequent doctoral studies.

The Master's program has a standard duration of four semesters. In the first two semesters,

through courses that focus on knowledge transfer, the technical-methodological foundation for the Master's qualification is established. In the third semester, by working on case studies in teams and integrated didactic reflection formats, which are based on current research projects, not only the technical-methodological but also the social and individual competences of the students are expanded. In the fourth semester, the students deal with a current and complex problem and conclude the program by writing a scientific Master's thesis.

0.2 Graduate Profile

Graduates of the Master's program in Automation & IT have a solid domain knowledge in the areas of industrial systems, energy systems and measurement systems. They are trained in data science, optimization, automation, modelling and simulation to be able to develop and design automation and autonomous systems, especially for the mentioned domains. Automation systems, which are heavily influenced by developments in the field of Information Technology (IT), typically include machines, equipment, processes, or other technical systems that can operate autonomously depending on the level of automation.

The graduates can identify problems in an interdisciplinary and global environment, formulating tasks, and solving these methodically. In doing so, they consider aspects from engineering, information technology, business management, as well as organizational, ethical, ecological, and social perspectives. Their methodical thinking is based on a technical-scientific foundation, enabling them to apply models, concepts, and theories to both familiar and new questions in the respective application context. They utilize in-depth knowledge from the disciplines

- Infrastructure and integration industrial, energy and measurement systems,
- Modeling and simulation of technical processes,
- Advanced control, smart automation and robotics,
- Optimization,
- Data Science, Machine Learning and AI,
- Industrial communication and IT Security,
- Vertical integration of technical and business IT systems, as well as
- Digitalization of industrial production and smart grids

The graduates are qualified by their studies and the specific course contents to take up a professional activity in the fields of cross-industrial automation and information technology. They are especially suited for activities in the fields research and development, planning and project engineering, as well as operation and maintenance of technical systems in which automation and information technology methods, concepts, and technologies are applied. Upon completing their studies, they have the option to further refine their scientific profile through subsequent doctoral studies.

0.3 Fields of Action

The fields of action defined in the graduate profile (Chapter 2) can be directly assigned to the central working fields of

- Research and development,
- Planning and project engineering, as well as
- Operation and maintenance,

since the professional profiles of these three fields are characterized in everyday professional life by typical processes that are defined in the following fields of action.

Depending on the company size and organizational structure, these fields of actions may be overlapping or integrated into each other, especially planning and project engineering with operation and maintenance. Operation and maintenance engineers are also responsible for planning and project engineering of modifications and expansions of the facilities or processes they oversee.

0.3.1 Research and Development

Research and development (R&D) encompasses all purposeful and systematic activities based on scientific methods, with the aim of acquiring new knowledge, new technologies or new applications.

Traditionally, a distinction is made between basic research and applied research. For graduates of the Master's program in Automation & IT, applied research is particularly important, in which new or existing products, plants, machinery, processes, procedures, or services are developed or improved.

According to the above definition, the goal of R&D is the acquisition and application of new knowledge. This naturally presupposes that the engineer is familiar with the factual, conceptual, procedural, and metacognitive knowledge relevant to the specific task in the required depth.

In research and development, engineers generate new knowledge by applying, analyzing, and evaluating existing factual, conceptual, procedural, and metacognitive knowledge to develop or improve new or existing products, plants, machinery, processes, procedures, or services.

R&D in the field of cross-industrial automation technology is not limited to manufacturers of automation systems or components. Nowadays, almost all technical devices, processes, machinery, or plants contain automation components. The development and automation of these components requires their own R&D activities that are related to the scope and complexity of these components.

A traditional, and still successful, career path in engineering and thus in automation technology consists of the stages Bachelor, Master, Doctorate (PhD), several years of activity in research and development, followed by tasks in planning and project planning or operation and maintenance, the latter usually being associated with increasing responsibility and hierarchical advancement. Alternatively, for engineers with high scientific interest and the required qualifications, a return to the academic world is possible by accepting a professorship.

Planning and Project Engineering

In automation technology, planning and project engineering refers to all work processes that are required from the quotation phase to the complete commissioning of an automation system.

In the field of planning and project engineering, engineers design and implement new automation systems by selecting, procuring, configuring, and integrating subsystems into an entire system based on solid expert knowledge to develop or improve new or existing products, plants, machinery, processes, procedures, or services.

Manufacturing companies, which are the clients for planning and project planning services, either have their own specialized departments focusing on planning and project planning or assign these tasks to engineers who are active in production and maintenance. Regardless of this organizational decision, especially in the fields of automation and electrical engineering, the majority of planning and project engineering services are provided by external service companies that specialize in this specific field of action. Moreover, among manufacturers of automation systems, a trend reversal can be observed: after decades of downsizing, there has recently been

a significant increase in personnel resources for the field of planning and project engineering.

Operation and Maintenance

The operation of (large) technical facilities is generally complex and capital-intensive. In the power industry, manufacturing and process industries, all plants are nowadays automated with an increasing trend. Alongside operation and maintenance, which primarily serves to ensure the availability of the facilities, the continuous optimization of all parameters that affect the profitability of a facility or process represents a core task for all engineers working in the areas of operation and maintenance.

In the field of operation and maintenance, automation and IT engineers enable the operation of facilities, machines, processes, or procedures by analyzing and evaluating the behavior of (automation and electrical) technical systems based on their solid expertise, and repairing and improving them as needed to achieve the generally intended profit from operating the facilities, machines, processes, or procedures.

Integration of Planning, Project Engineering, Operation and Maintenance

Depending on the size and organizational structure of a company, engineers from the operation and maintenance sector are also responsible for the planning and project engineering of modifications and expansions of the facilities or processes they oversee. In industry, they act in this capacity as clients for company-internal specialist units or external suppliers. In companies or production facilities that are supported by larger employee teams, engineers with a Master's degree or doctorate are often employed in leadership positions.

1 Module

1.1 Control of Technical Systems

Modulnummer	CT-01
Modulbezeichnung	Control of Technical Systems
Art des Moduls	Obermodul von Digital Signal Processing and Optoelectronics, Linear, Nonlinear and Model Predictive Control, Automation of Discrete Event Systems, Protection Automation and Control in Electrical Energy Supply
ECTS credits	14
Sprache	Englisch
Dauer des Moduls	2 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Winter- und Sommersemester
Modulverantwortliche*r	Prof. Dr. Rainer Scheuring (F10)
Dozierende	Prof. Dr. Michael Freiburg (F10) Prof. Dr. Sebastian Kraft (F10) Prof. Dr. Rainer Scheuring (F10)

Learning Outcome

Students can

- generate, manipulate and analyze digital and optical signals
- design, analyze, evaluate and control continuous systems
- design, analyze, evaluate and control discrete event systems
- design, analyze, evaluate, control and protect electrical energy systems

by

- understanding and applying digital signal processing theory
- understanding and applying theoretical concepts of optoelectronics
- understanding and applying linear, nonlinear and model predictive control theory
- understanding and applying discrete event control theory
- understanding and applying electrical system theory
- using “state of the art” analysis and design software
- summarizing results in reports
- presenting results in oral presentations

to

- be able to carry out design tasks such as system or plant design, controller design, etc.
- be qualified for a professional career as automation engineer

Modulinhalte

Lectures:

- a) Digital Signal Processing and Optoelectronics

- b) Linear, Nonlinear and Model Predictive Control
- c) Automation of Discrete Event Systems
- d) Protection, Automation and Control in Electrical Energy Supply

Lecturer:

- a) Prof. Dr. Sebastian Kraft
- b) Prof. Dr. Rainer Scheuring
- c) Prof. Dr. Rainer Scheuring
- d) Prof. Dr. Michael Freiburg

Credit Points:

- a) 4 CP
- b) 5 CP
- c) 2 CP
- d) 3 CP

Content:

- a) Digital Signal Processing and Optoelectronics
 - Conversion of signals (D/A, A/D), discrete level and time, impact of analogue environment
 - Transfer functions in S plane
 - Sampling theory fundamentals, Z-transformation, mapping S-Z-plane
 - Fundamentals of digital filters, transposed systems, DFT/FFT
 - Multi-rate signal processing, sample rate conversion
 - Optical signals
 - Fourier optics (fourier basics, transfer function, convolution, autocorrelation, filtering (high pass, low pass,...), point spread function, sampling theorem, applications)
 - Statistical optics (intensity, coherence functions, interference, coherence tomography)
 - Acousto optics
 - Fibers and switches
 - Laser spectroscopy
- b) Linear, Nonlinear and Model Predictive Control
 - State space approach
 - Interconnected systems and feedback
 - Stability
 - Reachability, Observability and Controllability
 - State feedback and output feedback
 - Observers
 - Structural characteristics of non-linear systems
 - Model-based predictive control systems
 - Internal model control and Smith predictor
 - Linear model predictive control (MPC)
 - Nonlinear model predictive control (NMPC)
 - Override control
 - Implementation concepts of major manufacturers
- c) Automation of Discrete Event Systems
 - Analysis of discrete event systems
 - Design of discrete event systems

- Safety oriented discrete event systems
 - Automation of hybrid dynamic systems
- d) Protection, Automation and Control in Electrical Energy Supply
- Short circuit calculations
 - Information systems in electric energy grids
 - Protection systems
 - Substation communication
 - State estimation
 - Voltage and reactive power control
 - Testing and Monitoring

Lehr- und Lernmethoden

Lecture, Tutorial, Laboratory Course, Team Project

Empfohlene Literatur

- B.E.A. Saleh and M.C. Teich: Fundamentals of Photonics, Wiley, 2007
- Girod, et.al.: Signals and Systems. ISBN 0-471-98800-6
- Proakis: Digital Signal Processing. ISBN 0-13-394289-9
- Diniz, et.al.: Digital Signal Processing. ISBN 0-521-78175-2
- Vaidyanathan, P.P.: Multirate Systems and Filter Banks. ISBN 0-13-605718-7
- Astrom, K.J., Hagglund, T.: Advanced PID Control, ISA, Research Triangle Park, 2006
- William, R.L., Lawrence, D.A.: Linear State-Space Control Systems. Wiley, 2007
- Liebermann, N.P.: Troubleshooting Process Plant Control. Wiley, 2008
- Ziegler, G.: Digitaler Differentialschutz, Publics Publishing , 2013
- Ziegler, G.: Digitaler Distanzschutz, Publics Publishing, 2008
- Schossig, W.: Netzschutztechnik, VDE, 2001
- Rashid, M.: Energy Systems in Electrical Engineering, Springer
- Gómez-Expósito, et al: Electric Energy Systems – Analysis and Operation, CRC Press, 2009
- Sivanagaraju, S.: Power system operation and control, Pearson, 2010

Prüfungsformen	Mündliche Prüfung Projektarbeit Klausurarbeit
Workload	420 h
Präsenzzeit	185 h (185 h Vorlesung)
Selbststudium	235 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1)

Besonderheiten	Weighting factors for finale module marking: (4 * a) + 5 * b) + 2 * c) + 3 * d)) / 14
Letzte Aktualisierung am	25.09.2026

1.1.1 Automation of Discrete Event Systems

Modulnummer	ADES
Modulbezeichnung	Automation of Discrete Event Systems
Art des Moduls	Teilmodul von Control of Technical Systems
ECTS credits	2
Sprache	Englisch
Dauer des Moduls	1 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Winter- und Sommersemester
Modulverantwortliche*r	Prof. Dr. Rainer Scheuring (F10)
Dozierende	Prof. Dr. Rainer Scheuring (F10)

Learning Outcome

Students can

- generate, manipulate and analyze digital and optical signals
- design, analyze, evaluate and control continuous systems
- design, analyze, evaluate and control discrete event systems
- design, analyze, evaluate, control and protect electrical energy systems

by

- understanding and applying digital signal processing theory
- understanding and applying theoretical concepts of optoelectronics
- understanding and applying linear, nonlinear and model predictive control theory
- understanding and applying discrete event control theory
- understanding and applying electrical system theory
- using “state of the art” analysis and design software
- summarizing results in reports
- presenting results in oral presentations

to

- be able to carry out design tasks such as system or plant design, controller design, etc.
- be qualified for a professional career as automation engineer

Modulinhalte

- Analysis of discrete event systems
- Design of discrete event systems
- Safety oriented discrete event systems
- Automation of hybrid dynamic systems

Lehr- und Lernmethoden

Lecture, Tutorial, Laboratory Course, Team Project

Empfohlene Literatur

- B.E.A. Saleh and M.C. Teich: Fundamentals of Photonics, Wiley, 2007
- Girod, et.al.: Signals and Systems. ISBN 0-471-98800-6
- Proakis: Digital Signal Processing. ISBN 0-13-394289-9
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- Ziegler, G.: Digitaler Distanzschutz, Publics Publishing, 2008
- Schossig, W.: Netzschutztechnik, VDE, 2001
- Rashid, M.: Energy Systems in Electrical Engineering, Springer
- Gómez-Expósito, et al: Electric Energy Systems – Analysis and Operation, CRC Press, 2009
- Sivanagaraju, S.: Power system operation and control, Pearson, 2010

Prüfungsformen	Mündliche Prüfung Projektarbeit Klausurarbeit
Workload	60 h
Präsenzzeit	0 h
Selbststudium	60 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1)
Besonderheiten	Keine
Letzte Aktualisierung am	25.09.2026

1.1.2 Digital Signal Processing and Optoelectronics

Modulnummer	DSPO
Modulbezeichnung	Digital Signal Processing and Optoelectronics
Art des Moduls	Teilmodul von Control of Technical Systems
ECTS credits	4
Sprache	Englisch
Dauer des Moduls	1 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Winter- und Sommersemester
Modulverantwortliche*r	Prof. Dr. Sebastian Kraft (F10) Prof. Dr. Rainer Scheuring (F10)
Dozierende	Prof. Dr. Sebastian Kraft (F10)

Learning Outcome

Students can

- generate, manipulate and analyze digital and optical signals
- design, analyze, evaluate and control continuous systems
- design, analyze, evaluate and control discrete event systems
- design, analyze, evaluate, control and protect electrical energy systems

by

- understanding and applying digital signal processing theory
- understanding and applying theoretical concepts of optoelectronics
- understanding and applying linear, nonlinear and model predictive control theory
- understanding and applying discrete event control theory
- understanding and applying electrical system theory
- using “state of the art” analysis and design software
- summarizing results in reports
- presenting results in oral presentations

to

- be able to carry out design tasks such as system or plant design, controller design, etc.
- be qualified for a professional career as automation engineer

Modulinhalte

- Conversion of signals (D/A, A/D), discrete level and time, impact of analogue environment
- Transfer functions in S plane
- Sampling theory fundamentals, Z-transformation, mapping S-Z-plane
- Fundamentals of digital filters, transposed systems, DFT/FFT
- Multi-rate signal processing, sample rate conversion
- Optical signals
- Fourier optics (fourier basics, transfer function, convolution, autocorrelation, filtering (high pass, low pass,...), point spread function, sampling theorem, applications)

- Statistical optics (intensity, coherence functions, interference, coherence tomography)
- Acousto optics
- Fibers and switches
- Laser spectroscopy

Lehr- und Lernmethoden

Lecture, Tutorial, Laboratory Course, Team Project

Empfohlene Literatur

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- Gómez-Expósito, et al: Electric Energy Systems – Analysis and Operation, CRC Press, 2009
- Sivanagaraju, S.: Power system operation and control, Pearson, 2010

Prüfungsformen	Mündliche Prüfung Projektarbeit Klausurarbeit
Workload	120 h
Präsenzzeit	0 h
Selbststudium	120 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1)
Besonderheiten	Keine
Letzte Aktualisierung am	25.09.2026

1.1.3 Linear, Nonlinear and Model Predictive Control

Modulnummer	LN MPC
Modulbezeichnung	Linear, Nonlinear and Model Predictive Control
Art des Moduls	Teilmodul von Control of Technical Systems
ECTS credits	5
Sprache	Englisch
Dauer des Moduls	1 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Winter- und Sommersemester
Modulverantwortliche*r	Prof. Dr. Rainer Scheuring (F10)
Dozierende	Prof. Dr. Rainer Scheuring (F10)

Learning Outcome

Students can

- generate, manipulate and analyze digital and optical signals
- design, analyze, evaluate and control continuous systems
- design, analyze, evaluate and control discrete event systems
- design, analyze, evaluate, control and protect electrical energy systems

by

- understanding and applying digital signal processing theory
- understanding and applying theoretical concepts of optoelectronics
- understanding and applying linear, nonlinear and model predictive control theory
- understanding and applying discrete event control theory
- understanding and applying electrical system theory
- using “state of the art” analysis and design software
- summarizing results in reports
- presenting results in oral presentations

to

- be able to carry out design tasks such as system or plant design, controller design, etc.
- be qualified for a professional career as automation engineer

Modulinhalte

- State space approach
- Interconnected systems and feedback
- Stability
- Reachability, Observability and Controllability
- State feedback and output feedback
- Observers
- Structural characteristics of non-linear systems
- Model-based predictive control systems
- Internal model control and Smith predictor

- Linear model predictive control (MPC)
- Nonlinear model predictive control (NMPC)
- Override control
- Implementation concepts of major manufacturers

Lehr- und Lernmethoden

Lecture, Tutorial, Laboratory Course, Team Project

Empfohlene Literatur

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- Rashid, M.: Energy Systems in Electrical Engineering, Springer
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- Sivanagaraju, S.: Power system operation and control, Pearson, 2010

Prüfungsformen	Mündliche Prüfung Projektarbeit Klausurarbeit
Workload	150 h
Präsenzzeit	0 h
Selbststudium	150 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1)
Besonderheiten	Keine
Letzte Aktualisierung am	25.09.2026

1.1.4 Protection Automation and Control in Electrical Energy Supply

Modulnummer	PACEES
Modulbezeichnung	Protection Automation and Control in Electrical Energy Supply
Art des Moduls	Teilmodul von Control of Technical Systems
ECTS credits	3
Sprache	Englisch
Dauer des Moduls	1 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Winter- und Sommersemester
Modulverantwortliche*r	Prof. Dr. Michael Freiburg (F10) Prof. Dr. Rainer Scheuring (F10)
Dozierende	Prof. Dr. Michael Freiburg (F10)

Learning Outcome

Students can

- generate, manipulate and analyze digital and optical signals
- design, analyze, evaluate and control continuous systems
- design, analyze, evaluate and control discrete event systems
- design, analyze, evaluate, control and protect electrical energy systems

by

- understanding and applying digital signal processing theory
- understanding and applying theoretical concepts of optoelectronics
- understanding and applying linear, nonlinear and model predictive control theory
- understanding and applying discrete event control theory
- understanding and applying electrical system theory
- using “state of the art” analysis and design software
- summarizing results in reports
- presenting results in oral presentations

to

- be able to carry out design tasks such as system or plant design, controller design, etc.
- be qualified for a professional career as automation engineer

Modulinhalte

- Short circuit calculations
- Information systems in electric energy grids
- Protection systems
- Substation communication
- State estimation
- Voltage and reactive power control
- Testing and Monitoring

Lehr- und Lernmethoden

Lecture, Tutorial, Laboratory Course, Team Project

Empfohlene Literatur

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- Rashid, M.: Energy Systems in Electrical Engineering, Springer
- Gómez-Expósito, et al: Electric Energy Systems – Analysis and Operation, CRC Press, 2009
- Sivanagaraju, S.: Power system operation and control, Pearson, 2010

Prüfungsformen	Mündliche Prüfung Projektarbeit Klausurarbeit
Workload	90 h
Präsenzzeit	0 h
Selbststudium	90 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1)
Besonderheiten	Keine
Letzte Aktualisierung am	25.09.2026

1.2 Industrial Communication and Information Security in Industrial Automation

Modulnummer	IN-01
Modulbezeichnung	Industrial Communication and Information Security in Industrial Automation
Art des Moduls	Obermodul von Industrial Communication, Industrial IoT, IT-Security
ECTS credits	12
Sprache	Englisch
Dauer des Moduls	2 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Winter- und Sommersemester
Modulverantwortliche*r	Prof. Dr. Felix Hackelöer (F10)
Dozierende	Prof. Dr. Felix Hackelöer (F10)

Learning Outcome

Students can

- evaluate, plan and configure industrial communication systems
- evaluate, plan and configure industrial IT-security systems

by

- understanding the principles of real-time Ethernet solutions and their applications in Automation including TSN, PROFINET and OPC UA
- understanding the difference of horizontal and vertical communication
- gaining detailed knowledge and experience in PROFINET regarding concept, engineering, diagnosis and maintenance
- understanding the requirements and functionality of network devices and controllers
- analyzing and evaluating network traffic in real-time applications by means of tools
- installing and configuring network devices
- planning and commissioning of network installations
- understanding connectivity architectures for Industrial Internet of Things (IIoT)
- understanding current technologies and protocols for IIoT
- evaluating the pros and cons of various protocols
- understanding industrial security objectives (availability, integrity, confidentiality)
- analyzing security objectives in IT and industrial automation scenarios
- comprehending international security standards for automation such as VDI 2182 and IEC 61443
- understanding the roles of vendors, system integrators and asset owners (end users)

- determining and evaluating system security vulnerabilities
- understanding and applying risk analysis methods to develop and evaluate measures
- evaluating typical threats, risks and measures in industrial automation scenarios
- developing methods to determine vulnerabilities
- understand encryption methodology incl. signatures
- estimating security tool limitations
- understanding firewall technology
- planning and configuring firewall systems
- summarizing results in reports
- presenting results in oral presentations

to

- be able to design, manage and maintain industrial automation systems
- be qualified for a professional career as automation engineer

Modulinhalte

Lectures:

- a) Industrial Communication
- b) Industrial IoT
- c) IT-Security

Lecturer:

- a) Prof. Dr. Klasen
- b) Prof. Dr. Hackelöer
- c) Prof. Dr. Hackelöer

Credit Points:

- a) 3 CP
- b) 5 CP
- c) 4 CP

Content:

- a) Industrial Communication
 - Ethernet-based industrial communication (focus on PROFINET)
 - Network analysis of real-time Ethernet networks
 - Network devices (switches, routers)
 - Architecture of plant networks vs. corporate networks
 - Integration of plant network and corporate network
 - Practical part:
 - PROFINET engineering and commissioning Workshop
 - Configuring network devices
 - Designing and configuring PROFINET applications including M2M
- b) Industrial IoT

- Introduction into Industrial IoT and ‘Industrie 4.0’
- Designating factors of industrial IoT applications
- IIoT connectivity, interfaces and protocols, such as MQTT, OPC UA
- Interfacing systems via OPC UA
- Architecture of vertical and horizontal IIoT applications
- IoT platforms and cloud-based systems
- IIoT Semantics and their implementation, e.g. via OPC UA
- Digital twins
- Handling of data
- Principles and terminology of MES (ISA-95)
- Industrial implementation examples, focus on OPC UA and MQTT

c) IT-Security

- Introduction into basic terms of IT security (security objectives, mechanisms, example scenarios)
- The Information security management system – instruments and methods used by management to systematically control (i.e., plan, put in place, implement, monitor, and improve) tasks and activities relating to IT security
- International standards on IT security, e.g. IEC 62443
- Cryptographic procedures as mechanisms to achieve security objectives - current cryptographic standards
- Principles and mechanisms of authentication
- TCP/IP based network and service security (weaknesses, attacks, examples)
- Firewall and IPS systems (application level gateways, packet filters, remote access)
- Specific requirements and conditions of industrial automation
- Threads and risk assessment
- Security aspects of Ethernet based automation protocols
- Functional security limitations and interfaces
- Design aspects and typical architectures of secure automation devices and systems
- Vulnerability Test and development of test cases for benchmarks and audits
- Security & Safety

Lehr- und Lernmethoden

Lecture, Tutorial, Laboratory Course

Empfohlene Literatur

- Klasen, F. et al.; Industrial Communication with Fieldbus and Ethernet VDE Verlag, 9.11.2011, ISBN 978-3-8007-3358-3
- Anderson, Ross: Security Engineering, John Wiley & Sons Inc, 2001
- Eckert, Claudia: IT-Sicherheit. Konzepte - Verfahren - Protokolle, Oldenbourg, 2006
- Schneier, Bruce : Practical Cryptography, John Wiley & Sons, 2003
- Schneier, Bruce : Secrets & Lies. IT-Sicherheit in einer vernetzten Welt, Dpunkt Verlag, 2006
- <http://www.securityfocus.com> (aktuelle Sicherheitsmeldungen)
- Normen und Richtlinien: Manufacturing and Control Systems Security ISA SP99
- VDE/VDI 2182
- Meyer, H., Fuchs, F., Thiel, K.: Manufacturing Execution Systems: Optimal Design, Planning, and Deployment. Mcgraw Hill Book Co, 2009.
- Kletti, H.(Editor): Manufacturing Execution System - MES. Springer Berlin Heidelberg, 2010.

- Schleipen: Praxishandbuch OPC UA, ISBN 978-3-8343-3413-8
- Lea: Internet of Things for Architects, ISBN 978-1-78847-059-9
- <http://mqtt.org/>
- <https://www.amqp.org/>
- IEC 62443 international norm

Prüfungsformen	Mündliche Prüfung Projektarbeit Klausurarbeit
Workload	360 h
Präsenzzeit	154 h (84 h Vorlesung, 70 h Projektarbeit)
Selbststudium	206 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1)
Besonderheiten	Weighting factors for finale module marking: (3 * a) + 5 * b) + 4 * c)) / 12
Letzte Aktualisierung am	25.09.2026

1.2.1 IT-Security

Modulnummer	ITS
Modulbezeichnung	IT-Security
Art des Moduls	Teilmodul von Industrial Communication and Information Security in Industrial Automation
ECTS credits	4
Sprache	Englisch
Dauer des Moduls	1 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Winter- und Sommersemester
Modulverantwortliche*r	Prof. Dr. Felix Hackelöer (F10)
Dozierende	Prof. Dr. Felix Hackelöer (F10)

Learning Outcome

Students can

- evaluate, plan and configure industrial communication systems
- evaluate, plan and configure industrial IT-security systems

by

- understanding the principles of real-time Ethernet solutions and their applications in Automation including TSN, PROFINET and OPC UA
- understanding the difference of horizontal and vertical communication
- gaining detailed knowledge and experience in PROFINET regarding concept, engineering, diagnosis and maintenance
- understanding the requirements and functionality of network devices and controllers
- analyzing and evaluating network traffic in real-time applications by means of tools
- installing and configuring network devices
- planning and commissioning of network installations
- understanding connectivity architectures for Industrial Internet of Things (IIoT)
- understanding current technologies and protocols for IIoT
- evaluating the pros and cons of various protocols
- understanding industrial security objectives (availability, integrity, confidentiality)
- analyzing security objectives in IT and industrial automation scenarios
- comprehending international security standards for automation such as VDI 2182 and IEC 61443
- understanding the roles of vendors, system integrators and asset owners (end users)
- determining and evaluating system security vulnerabilities

- understanding and applying risk analysis methods to develop and evaluate measures
- evaluating typical threats, risks and measures in industrial automation scenarios
- developing methods to determine vulnerabilities
- understand encryption methodology incl. signatures
- estimating security tool limitations
- understanding firewall technology
- planning and configuring firewall systems
- summarizing results in reports
- presenting results in oral presentations

to

- be able to design, manage and maintain industrial automation systems
- be qualified for a professional career as automation engineer

Modulinhalte

Lectures:

- Introduction into basic terms of IT security (security objectives, mechanisms, example scenarios)
- The Information security management system – instruments and methods used by management to systematically control (i.e., plan, put in place, implement, monitor, and improve) tasks and activities relating to IT security
- International standards on IT security, e.g. IEC 62443
- Cryptographic procedures as mechanisms to achieve security objectives - current cryptographic standards
- Principles and mechanisms of authentication
- TCP/IP based network and service security (weaknesses, attacks, examples)
- Firewall and IPS systems (application level gateways, packet filters, remote access)
- Specific requirements and conditions of industrial automation
- Threads and risk assessment
- Security aspects of Ethernet based automation protocols
- Functional security limitations and interfaces
- Design aspects and typical architectures of secure automation devices and systems
- Vulnerability Test and development of test cases for benchmarks and audits
- Security & Safety

Lehr- und Lernmethoden

Lecture, Tutorial, Laboratory Course

Empfohlene Literatur

- Klasen, F. et al.; Industrial Communication with Fieldbus and Ethernet VDE Verlag, 9.11.2011, ISBN 978-3-8007-3358-3
- Anderson, Ross: Security Engineering, John Wiley & Sons Inc, 2001
- Eckert, Claudia: IT-Sicherheit. Konzepte - Verfahren - Protokolle, Oldenbourg, 2006
- Schneier, Bruce : Practical Cryptography, John Wiley & Sons, 2003

- Schneier, Bruce : Secrets & Lies. IT-Sicherheit in einer vernetzten Welt, Dpunkt Verlag, 2006
- <http://www.securityfocus.com> (aktuelle Sicherheitsmeldungen)
- Normen und Richtlinien: Manufacturing and Control Systems Security ISA SP99
- VDE/VDI 2182
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- Kletti, H.(Editor): Manufacturing Execution System - MES. Springer Berlin Heidelberg, 2010.
- Schleipen: Praxishandbuch OPC UA, ISBN 978-3-8343-3413-8
- Lea: Internet of Things for Architects, ISBN 978-1-78847-059-9
- <http://mqtt.org/>
- <https://www.amqp.org/>
- IEC 62443 international norm

Prüfungsformen	Mündliche Prüfung Projektarbeit Klausurarbeit
Workload	120 h
Präsenzzeit	34 h (24 h Vorlesung, 10 h Projektarbeit)
Selbststudium	86 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1)
Besonderheiten	Keine
Letzte Aktualisierung am	25.09.2026

1.2.2 Industrial Communication

Modulnummer	ICOM
Modulbezeichnung	Industrial Communication
Art des Moduls	Teilmodul von Industrial Communication and Information Security in Industrial Automation
ECTS credits	3
Sprache	Englisch
Dauer des Moduls	1 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Wintersemester
Modulverantwortliche*r	Prof. Dr. Peter Kern (F10)
Dozierende	Prof. Dr. Peter Kern (F10)

Learning Outcome

Students can

- evaluate, plan and configure industrial communication systems
- evaluate, plan and configure industrial IT-security systems

by

- understanding the principles of real-time Ethernet solutions and their applications in Automation including TSN, PROFINET and OPC UA
- understanding the difference of horizontal and vertical communication
- gaining detailed knowledge and experience in PROFINET regarding concept, engineering, diagnosis and maintenance
- understanding the requirements and functionality of network devices and controllers
- analyzing and evaluating network traffic in real-time applications by means of tools
- installing and configuring network devices
- planning and commissioning of network installations
- understanding connectivity architectures for Industrial Internet of Things (IIoT)
- understanding current technologies and protocols for IIoT
- evaluating the pros and cons of various protocols
- understanding industrial security objectives (availability, integrity, confidentiality)
- analyzing security objectives in IT and industrial automation scenarios
- comprehending international security standards for automation such as VDI 2182 and IEC 61443
- understanding the roles of vendors, system integrators and asset owners (end users)
- determining and evaluating system security vulnerabilities

- understanding and applying risk analysis methods to develop and evaluate measures
- evaluating typical threats, risks and measures in industrial automation scenarios
- developing methods to determine vulnerabilities
- understand encryption methodology incl. signatures
- estimating security tool limitations
- understanding firewall technology
- planning and configuring firewall systems
- summarizing results in reports
- presenting results in oral presentations

to

- be able to design, manage and maintain industrial automation systems
- be qualified for a professional career as automation engineer

Modulinhalte

- Ethernet-based industrial communication (focus on PROFINET)
- Network analysis of real-time Ethernet networks
- Network devices (switches, routers)
- Architecture of plant networks vs. corporate networks
- Integration of plant network and corporate network
- Practical part:
 - PROFINET engineering and commissioning Workshop
 - Configuring network devices
 - Designing and configuring PROFINET applications including M2M

Empfohlene Literatur

- Klasen, F. et al.; Industrial Communication with Fieldbus and Ethernet VDE Verlag, 9.11.2011, ISBN 978-3-8007-3358-3
- Anderson, Ross: Security Engineering, John Wiley & Sons Inc, 2001
- Eckert, Claudia: IT-Sicherheit. Konzepte - Verfahren - Protokolle, Oldenbourg, 2006
- Schneier, Bruce : Practical Cryptography, John Wiley & Sons, 2003
- Schneier, Bruce : Secrets & Lies. IT-Sicherheit in einer vernetzten Welt, Dpunkt Verlag, 2006
- <http://www.securityfocus.com> (aktuelle Sicherheitsmeldungen)
- Normen und Richtlinien: Manufacturing and Control Systems Security ISA SP99
- VDE/VDI 2182

Prüfungsformen	Mündliche Prüfung Projektarbeit Klausurarbeit
Workload	90 h
Präsenzzeit	0 h
Selbststudium	90 h

Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1)
Besonderheiten	Keine
Letzte Aktualisierung am	25.09.2026

1.2.3 Industrial IoT

Modulnummer	IIOT
Modulbezeichnung	Industrial IoT
Art des Moduls	Teilmodul von Industrial Communication and Information Security in Industrial Automation
ECTS credits	5
Sprache	Englisch
Dauer des Moduls	1 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Winter- und Sommersemester
Modulverantwortliche*r	Prof. Dr. Felix Hackelöer (F10)
Dozierende	Prof. Dr. Felix Hackelöer (F10)

Learning Outcome

Students can

- evaluate, plan and configure industrial communication systems
- evaluate, plan and configure industrial IT-security systems

by

- understanding the principles of real-time Ethernet solutions and their applications in Automation including TSN, PROFINET and OPC UA
- understanding the difference of horizontal and vertical communication
- gaining detailed knowledge and experience in PROFINET regarding concept, engineering, diagnosis and maintenance
- understanding the requirements and functionality of network devices and controllers
- analyzing and evaluating network traffic in real-time applications by means of tools
- installing and configuring network devices
- planning and commissioning of network installations
- understanding connectivity architectures for Industrial Internet of Things (IIoT)
- understanding current technologies and protocols for IIoT
- evaluating the pros and cons of various protocols
- understanding industrial security objectives (availability, integrity, confidentiality)
- analyzing security objectives in IT and industrial automation scenarios
- comprehending international security standards for automation such as VDI 2182 and IEC 61443
- understanding the roles of vendors, system integrators and asset owners (end users)
- determining and evaluating system security vulnerabilities

- understanding and applying risk analysis methods to develop and evaluate measures
- evaluating typical threats, risks and measures in industrial automation scenarios
- developing methods to determine vulnerabilities
- understand encryption methodology incl. signatures
- estimating security tool limitations
- understanding firewall technology
- planning and configuring firewall systems
- summarizing results in reports
- presenting results in oral presentations

to

- be able to design, manage and maintain industrial automation systems
- be qualified for a professional career as automation engineer

Modulinhalte

Lectures:

- Introduction into Industrial IoT and ‘Industrie 4.0’
- Designating factors of industrial IoT applications
- IIoT connectivity, interfaces and protocols, such as MQTT, OPC UA
- Interfacing systems via OPC UA
- Architecture of vertical and horizontal IIoT applications
- IoT platforms and cloud-based systems
- IIoT Semantics and their implementation, e.g. via OPC UA
- Digital twins
- Handling of data
- Principles and terminology of MES (ISA-95)
- Industrial implementation examples, focus on OPC UA and MQTT

Lehr- und Lernmethoden

Lecture, Tutorial, Laboratory Course

Empfohlene Literatur

- Klasen, F. et al.; Industrial Communication with Fieldbus and Ethernet VDE Verlag, 9.11.2011, ISBN 978-3-8007-3358-3
- Anderson, Ross: Security Engineering, John Wiley & Sons Inc, 2001
- Eckert, Claudia: IT-Sicherheit. Konzepte - Verfahren - Protokolle, Oldenbourg, 2006
- Schneier, Bruce : Practical Cryptography, John Wiley & Sons, 2003
- Schneier, Bruce : Secrets & Lies. IT-Sicherheit in einer vernetzten Welt, Dpunkt Verlag, 2006
- <http://www.securityfocus.com> (aktuelle Sicherheitsmeldungen)
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- VDE/VDI 2182
- Meyer, H., Fuchs, F., Thiel, K.: Manufacturing Execution Systems: Optimal Design, Planning, and Deployment. Mcgraw Hill Book Co, 2009.

- Kletti, H.(Editor): Manufacturing Execution System - MES. Springer Berlin Heidelberg, 2010.
- Schleipen: Praxishandbuch OPC UA, ISBN 978-3-8343-3413-8
- Lea: Internet of Things for Architects, ISBN 978-1-78847-059-9
- <http://mqtt.org/>
- <https://www.amqp.org/>
- IEC 62443 international norm

Prüfungsformen	Mündliche Prüfung Projektarbeit Klausurarbeit
Workload	150 h
Präsenzzeit	150 h (150 h Vorlesung)
Selbststudium	Keine
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1)
Besonderheiten	Keine
Letzte Aktualisierung am	25.09.2026

1.3 Integration of Technical and Business Information Systems

Modulnummer	IS-01
Modulbezeichnung	Integration of Technical and Business Information Systems
Art des Moduls	Obermodul von Relational Databases, Enterprise Resource Planning Systems, Object-oriented Programming for Data Science
ECTS credits	9
Sprache	Englisch
Dauer des Moduls	2 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Winter- und Sommersemester
Modulverantwortliche*r	Prof. Dr. Rainer Scheuring (F10)
Dozierende	Prof. Dr. Johann Schaible (F10) Prof. Dr. Hartmut Westenberger (F10) Prof. Dr. Christian Wolf (F10)

Learning Outcome

Students can

- design and write object oriented program code using the Python language
- use relational databases
- evaluate technologies of Industrial Internet of Things and Manufacturing Execution Systems
- understand Enterprise Ressource Planning Systems

by

- understanding and using abstract classes, composition and data analysis functions
- comprehending the theoretical principles of database systems and their application to modelling and implementing databases,
- creating complex database queries, data definitions and data changes using SQL programming
- using transactions, multi-user synchronisation and procedures for fault recovery and ensuring data integrity
- understanding active database concepts and applying them with Oracle PL/SQL
- comprehending MES architectures (Manufacturing Execution System)
- understanding the functionalities of central MES components and their evaluation
- using and parameterizing MES interfaces to superior and inferior systems
- comprehending basic technologies of information systems (client/server, web services, communication in client/server and service oriented structures) and their pros and cons
- modeling business processes and implementing small examples of business functions in an enterprise resource planning environment
- analyzing complex application systems in reference models
- evaluating the technology of application systems
- comprehending various integration models and integrating sub-systems
- summarizing results in reports

- presenting results in oral presentations

to

- be able to solve data science problems by developing fast and reliable object-oriented software
- be able to integrate automation systems, technical information systems and business information systems
- be qualified for a professional career as automation engineer

Modulinhalte

Lectures:

- a) Object oriented Programming for Data Science
- b) Relational Databases
- c) Enterprise Resource Planning Systems

Lecturer:

- a) Prof. Dr. Christian Wolf
- b) Prof. Dr. Johann Schaible
- c) Prof. Dr. Hartmut Westenberger

Credit Points:

- a) 3 CP
- b) 3 CP
- c) 3 CP

Content:

- a) Object oriented Programming for Data Science
 - Abstract data types, classes, objects, messages, Instance variables, methods, encapsulation, private and public access, class variables, constructors, class interface, class implementation
 - Classes and objects, private and public class members, constructors, initialization list, static data members, overloading, inline, separation of interface and implementation
 - Data structures, iterators and containers
 - Design, code and test a series of object-oriented programs to reenforce lecture content
 - Exception handling
 - Function overloading, operator overloading
 - Generic Types, Static and Dynamic Binding, Polymorphism, Overloading
 - Inheritance: Types of Inheritance, Construction, Destruction, Multiple Inheritance
- b) Relational Databases
 - Basic terms and architectures of databases
 - Database system creation
 - Principles of the relational model (relational algebra, query optimisation, functional dependencies, data integrity and normalisation)
 - Data modelling (Entity Relationship Model)
 - Implementation using a relational database system as an example
 - Database language SQL: DDL, DML, DAL
 - Constraints of the current SQL standard (SQL 2003)

- Transaction concepts
- Multi-user synchronisation
- Fault recovery and data security
- Active database concepts and fundamentals of Oracle PL/SQL

c) Enterprise Resource Planning Systems (ERP)

- Structure of ERP Systems, ERP Paradigms
- Basic Technologies (client/server, SOAP) and Technical Architecture
- Business Transaction and Transaction Monitor
- Process Modelling
- Programming and Implementation of Business Functions
- Middleware and Integration Models
- Web Service Based Integration

Lehr- und Lernmethoden

Lecture, Tutorial, Team Project

Empfohlene Literatur

- Lutz, M.: Programming Python - Powerful Object-Oriented Programming (ISBN: 0596158106)
- Gamma, E., Helm, R.: Design Patterns - Elements of Reusable Object-Oriented Software (ISBN: 0201633612)
- VanderPlas, J.: Python Data Science Handbook - Essential Tools for Working with Data (ISBN: 9781491912058)
- Geron, A.: Hands-On Machine Learning with Scikit-Learn and TensorFlow - Concepts, Tools, and Techniques to Build Intelligent Systems (ISBN: 1491962291)
- Chappell D. A.: Enterprise Service Bus. O'Reilly, 2004.
- Current publications of major manufacturers such as ORACLE, SAP, SIEMENS, etc.
- Elmasri, R, Navathe, R.: Fundamentals of Database Systems. Prentice Hall International, 6th edition, Global Edition, 2010.
- Garcia-Molina, Jeffrey D. Ullman Jennifer Widom, Database Systems: The Complete Book, Prentice Hall International, 2008.
- Josuttis N., M.: Soa in Practise. O'Reilly Media, 2007.
- Meyer, H., Fuchs, F., Thiel, K.: Manufacturing Execution Systems: Optimal Design, Planning, and Deployment. Mcgraw Hill Book Co, 2009.
- Kletti, H.(Editor): Manufacturing Execution System - MES. Springer Berlin Heidelberg, 2010.
- Schleipen: Praxishandbuch OPC UA, ISBN 978-3-8343-3413-8
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- <http://mqtt.org/>
- <https://www.amqp.org/>
- Van der Hoven H.: ERP and Business Processes. Llumina Press, 2009.

Prüfungsformen	Mündliche Prüfung Projektarbeit Klausurarbeit
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Workload	270 h
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Präsenzzeit	120 h (120 h Vorlesung)
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Selbststudium	150 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1)
Besonderheiten	Weighting factors for finale module marking: $(3 * a) + 3 * b + 3 * c) / 9$
Letzte Aktualisierung am	25.09.2026

1.3.1 Enterprise Resource Planning Systems

Modulnummer	ERP
Modulbezeichnung	Enterprise Resource Planning Systems
Art des Moduls	Teilmodul von Integration of Technical and Business Information Systems
ECTS credits	3
Sprache	Englisch
Dauer des Moduls	1 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Winter- und Sommersemester
Modulverantwortliche*r	Prof. Dr. Rainer Scheuring (F10) Prof. Dr. Hartmut Westenberger (F10)
Dozierende	Prof. Dr. Hartmut Westenberger (F10)

Learning Outcome

Students can

- design and write object oriented program code using the Python language
- use relational databases
- evaluate technologies of Industrial Internet of Things and Manufacturing Execution Systems
- understand Enterprise Ressource Planning Systems

by

- understanding and using abstract classes, composition and data analysis functions
- comprehending the theoretical principles of database systems and their application to modelling and implementing databases,
- creating complex database queries, data definitions and data changes using SQL programming
- using transactions, multi-user synchronisation and procedures for fault recovery and ensuring data integrity
- understanding active database concepts and applying them with Oracle PL/SQL
- comprehending MES architectures (Manufacturing Execution System)
- understanding the functionalities of central MES components and their evaluation
- using and parameterizing MES interfaces to superior and inferior systems
- comprehending basic technologies of information systems (client/server, web services, communication in client/server and service oriented structures) and their pros and cons
- modeling business processes and implementing small examples of business functions in an enterprise resource planning environment
- analyzing complex application systems in reference models
- evaluating the technology of application systems
- comprehending various integration models and integrating sub-systems
- summarizing results in reports
- presenting results in oral presentations

to

- be able to solve data science problems by developing fast and reliable object-oriented software
- be able to integrate automation systems, technical information systems and business information systems
- be qualified for a professional career as automation engineer

Modulinhalte

Lectures:

- Structure of ERP Systems, ERP Paradigms
- Basic Technologies (client/server, SOAP) and Technical Architecture
- Business Transaction and Transaction Monitor
- Process Modelling
- Programming and Implementation of Business Functions
- Middleware and Integration Models
- Web Service Based Integration

Lehr- und Lernmethoden

Lecture, Tutorial, Team Project

Empfohlene Literatur

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- Josuttis N., M.: Soa in Practise. O'Reilly Media, 2007.
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- Schleipen: Praxishandbuch OPC UA, ISBN 978-3-8343-3413-8
- [Lea: Internet of Things for Architects, ISBN 978-1-78847-059-9]
- <http://mqtt.org/>
- <https://www.amqp.org/>
- Van der Hoven H.: ERP and Business Processes. Llumina Press, 2009.

Prüfungsformen

Mündliche Prüfung
Klausurarbeit

Workload

90 h

Präsenzzeit	0 h
Selbststudium	90 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1)
Besonderheiten	Keine
Letzte Aktualisierung am	25.09.2026

1.3.2 Object-oriented Programming for Data Science

Modulnummer	OPDS MMW
Modulbezeichnung	Object-oriented Programming for Data Science
Art des Moduls	Teilmodul von Integration of Technical and Business Information Systems
ECTS credits	5
Sprache	Deutsch
Dauer des Moduls	1 Semester
Empfohlenes Studiensemester	1., 2. Semester
Häufigkeit des Angebots	Wintersemester
Modulverantwortliche*r	Prof. Dr. Peter Kern (F10) Prof. Dr. Christian Wolf (F10)
Dozierende	Prof. Dr. Peter Kern (F10) Prof. Dr. Christian Wolf (F10)

Learning Outcome

After Attending this course students will be able to

- apply the advanced principles and concepts of Object Oriented Programming and develop programs for basic data analytics,
- design and write object oriented programs using advanced Object Oriented constructs in Python,
- modify an existing Object-Oriented program,
- extensively test an Object-Oriented program,
- construct Program Libraries,
- demonstrate an understanding of the underlying principles and concepts of Object-Oriented Programming,
- document an Object-Oriented program, and
- perform basic data analytics,

by

- understanding abstract data types, classes, objects, messages, Instance variables, methods, encapsulation, private and public access, class variables, constructors, class interface, class implementation.
- understanding classes and objects, private and public class members, constructors, initialisation list, static data members, overloading, inline, separation of interface and implementation.
- understanding Data structures, iterators and containers.
- using error handling and debugging practices

in order to

- solve data science tasks by developing fast and reliable object-oriented software, and
- be qualified for a professional career as automation engineer developing digitalindustrial solutions.

Modulinhalte

a) Classes, Abstract Classes, Methods, Variables

- Abstract data types, classes, objects, messages, Instance variables, methods, encapsulation, private and public access, class variables, constructors, class interface, class implementation.
- Classes and objects, private and public class members, constructors, initialisation list, static data members, overloading, inline, separation of interface and implementation.

b) Composition

- Data structures, iterators and containers.
- Design, code and test a series of object-oriented programs to re-enforce lecture content.

c) Destructors

- Exception handling.
- Function overloading. Operator overloading.
- Generic Types, Static and Dynamic Binding, Polymorphism, Overloading.
- Inheritance: Types of Inheritance, Construction, Destruction, Multiple Inheritance.

d) Data analysis functions

- Data Preprocessing (Outlier Removal, Filters, Smoothing, etc.)
- Regression functions
- Classification methods
- Machine Learning models i.e. Random Forest
- AI models i.e. Neural Networks

Lehr- und Lernmethoden

Seminaristischer Unterricht, Projektarbeit, Fallstudien

Empfohlene Literatur

- Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython (ISBN: 1491957662)
- Einstieg in Python: Die Einführung für Programmieranfänger, inkl. Objektorientierung (ISBN: 3836273799)
- Machine Learning mit Python und Keras, TensorFlow 2 und Scikit-learn (ISBN: 374750213X)

Prüfungsformen	Hausarbeit Mündliche Prüfung Projektarbeit
Workload	150 h
Präsenzzeit	150 h (75 h Vorlesung, 75 h Projektarbeit)
Selbststudium	Keine
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Grundkenntnisse in der Programmierung
Anwesenheitspflicht	Keine

Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1, 2) Wirtschaftsingenieurwesen PO-2 (Sem. 1, 2)
Besonderheiten	Keine
Letzte Aktualisierung am	25.09.2026

1.3.3 Relational Databases

Modulnummer	RDB
Modulbezeichnung	Relational Databases
Art des Moduls	Teilmodul von Integration of Technical and Business Information Systems
ECTS credits	3
Sprache	Englisch
Dauer des Moduls	2 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Winter- und Sommersemester
Modulverantwortliche*r	Prof. Dr. Johann Schaible (F10) Prof. Dr. Rainer Scheuring (F10)
Dozierende	Prof. Dr. Johann Schaible (F10)

Learning Outcome

Students can

- design and write object oriented program code using the Python language
- use relational databases
- evaluate technologies of Industrial Internet of Things and Manufacturing Execution Systems
- understand Enterprise Ressource Planning Systems

by

- understanding and using abstract classes, composition and data analysis functions
- comprehending the theoretical principles of database systems and their application to modelling and implementing databases,
- creating complex database queries, data definitions and data changes using SQL programming
- using transactions, multi-user synchronisation and procedures for fault recovery and ensuring data integrity
- understanding active database concepts and applying them with Oracle PL/SQL
- comprehending MES architectures (Manufacturing Execution System)
- understanding the functionalities of central MES components and their evaluation
- using and parameterizing MES interfaces to superior and inferior systems
- comprehending basic technologies of information systems (client/server, web services, communication in client/server and service oriented structures) and their pros and cons
- modeling business processes and implementing small examples of business functions in an enterprise resource planning environment
- analyzing complex application systems in reference models
- evaluating the technology of application systems
- comprehending various integration models and integrating sub-systems
- summarizing results in reports
- presenting results in oral presentations

to

- be able to solve data science problems by developing fast and reliable object-oriented software
- be able to integrate automation systems, technical information systems and business information systems
- be qualified for a professional career as automation engineer

Modulinhalte

- Basic terms and architectures of databases
- Database system creation
- Principles of the relational model (relational algebra, query optimisation, functional dependencies, data integrity and normalisation)
- Data modelling (Entity Relationship Model)
- Implementation using a relational database system as an example
- Database language SQL: DDL, DML, DAL
- Constraints of the current SQL standard (SQL 2003)
- Transaction concepts
- Multi-user synchronisation
- Fault recovery and data security
- Active database concepts and fundamentals of Oracle PL/SQL

Lehr- und Lernmethoden

Lecture, Tutorial, Team Project

Empfohlene Literatur

- Lutz, M.: Programming Python - Powerful Object-Oriented Programming (ISBN: 0596158106)
- Gamma, E., Helm, R.: Design Patterns - Elements of Reusable Object-Oriented Software (ISBN: 0201633612)
- VanderPlas, J.: Python Data Science Handbook - Essential Tools for Working with Data (ISBN: 9781491912058)
- Geron, A.: Hands-On Machine Learning with Scikit-Learn and TensorFlow - Concepts, Tools, and Techniques to Build Intelligent Systems (ISBN: 1491962291)
- Chappell D. A.: Enterprise Service Bus. O'Reilly, 2004.
- Current publications of major manufacturers such as ORACLE, SAP, SIEMENS, etc.
- Elmasri, R, Navathe, R.: Fundamentals of Database Systems. Prentice Hall International, 6th edition, Global Edition, 2010.
- Garcia-Molina, Jeffrey D. Ullman Jennifer Widom, Database Systems: The Complete Book, Prentice Hall International, 2008.
- Josuttis N., M.: Soa in Practise. O'Reilly Media, 2007.
- Meyer, H., Fuchs, F., Thiel, K.: Manufacturing Execution Systems: Optimal Design, Planning, and Deployment. Mcgraw Hill Book Co, 2009.
- Kletti, H.(Editor): Manufacturing Execution System - MES. Springer Berlin Heidelberg, 2010.
- Schleipen: Praxishandbuch OPC UA, ISBN 978-3-8343-3413-8
- [Lea: Internet of Things for Architects, ISBN 978-1-78847-059-9]
- <http://mqtt.org/>
- <https://www.amqp.org/>
- Van der Hoven H.: ERP and Business Processes. Llumina Press, 2009.

Prüfungsformen	Hausarbeit Mündliche Prüfung Klausurarbeit
Workload	90 h
Präsenzzeit	0 h
Selbststudium	90 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1)
Besonderheiten	Weighting factors for finale module marking: $(3 * a) + 3 * b) + 3 * c) / 9$
Letzte Aktualisierung am	25.09.2026

1.4 Mess- und Sensortechnik

Modulnummer	MST MMW
Modulbezeichnung	Mess- und Sensortechnik
Art des Moduls	Pflichtmodul
ECTS credits	5
Sprache	Deutsch
Dauer des Moduls	1 Semester
Empfohlenes Studiensemester	1., 2. Semester
Häufigkeit des Angebots	Wintersemester
Modulverantwortliche*r	Prof. Dr. Sebastian Kraft (F10)
Dozierende	Prof. Dr. Sebastian Kraft (F10)

Learning Outcome

Die Teilnehmer*innen sind nach Besuch der Veranstaltung in der Lage,

- die Grundlagen der Messtechnik zu verstehen und anzuwenden,

indem sie

- Messtheorie und Messvorgänge kennen und verstehen,
- Messunsicherheiten berechnen und bewerten,
- Messsensoren kennen und auswählen,
- Messverfahren anpassen und implementieren und
- Messdaten visualisieren und analysieren,

um

- selbstständig Messsysteme zu konzipieren und zu bewerten.

Modulinhalte

- Grundlagen der Messtheorie
- Messunsicherheiten
- Arten und Aufbau von Sensoren
- Überblick über verschiedene Messverfahren
- Messdatendarstellung und -analyse
- Bewertung von Messungen
- Einsatz von Software zur Datenerfassung und -auswertung (Insbesondere Python und Jupyter-Notebooks)

Lehr- und Lernmethoden

Vorlesung und Praktika

Empfohlene Literatur

- Tränkle, H.-R.; Reindl, L (2015): Sensortechnik: Handbuch für Praxis und Wissenschaft. 2. Auflage. Springer Vieweg.

- Mühl, T. (2020): Elektrische Messtechnik: Grundlagen, Messverfahren, Anwendungen. 6. Auflage. Springer Vieweg.

Prüfungsformen	Mündliche Prüfung Präsentation
Workload	150 h
Präsenzzeit	60 h (60 h Vorlesung)
Selbststudium	90 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Wirtschaftsingenieurwesen PO-2 (Sem. 1, 2)
Besonderheiten	Keine
Letzte Aktualisierung am	25.09.2026

1.5 Modelling and Simulation of Technical Systems

Modulnummer	MS-01
Modulbezeichnung	Modelling and Simulation of Technical Systems
Art des Moduls	Obermodul von Modelling and Simulation of Discrete Event Systems, Modelling and Simulation of Continuous Systems, Data-Driven Modelling and Model Optimization, Modelling and Simulation of Electrical Energy Systems
ECTS credits	15
Sprache	Englisch
Dauer des Moduls	2 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Winter- und Sommersemester
Modulverantwortliche*r	Prof. Dr. Rainer Scheuring (F10)
Dozierende	Prof. Dr. Thomas Bartz-Beielstein (F10) Prof. Dr. Michael Freiburg (F10) Prof. Dr. Rainer Scheuring (F10)

Learning Outcome

Students can

- model and simulate continuous systems
- model and simulate discrete event systems
- model data based systems (big data)
- model and simulate electrical energy systems

by

- understanding and applying the concepts of modelling of continuous systems, discrete event systems, data based systems, and electrical energy systems
- understanding the concepts of continuous and discrete event simulators
- evaluating advantages and disadvantages of numerical integration methods
- applying modelling and simulation concepts to real-world technical problems
- designing simulation models of technical systems
- evaluating the quality of the simulation models
- performing simulation experiments
- using tools from statistical learning for modeling and understanding complex data sets
- applying standardized processes (e.g., the CRISP-DM process) to investigate complex data
- summarizing results in reports
- presenting results in oral presentations

to

- develop a deep understanding of the behavior of technical systems
- analyze and understand data from these systems
- be able to carry out design tasks such as system or plant design, controller design, etc. with the aid of simulation tools
- be qualified for a professional career as automation engineer

Modulinhalte

Lectures:

- a) Modelling and Simulation of Continuous Systems
- b) Modelling and Simulation of Discrete Event Systems
- c) Data-driven Modelling and Model Optimization
- d) Modelling and Simulation of Electrical Energy Systems

Lecturer:

- a) Prof. Dr. Rainer Scheuring
- b) Prof. Dr. Rainer Scheuring
- c) Prof. Dr. Thomas Bartz-Beielstein
- d) Prof. Dr. Michael Freiburg

Credit Points:

- a) 4 CP
- b) 2 CP
- c) 5 CP
- d) 4 CP

Content:

a) Modelling and Simulation of Continuous Systems

- Modelling mechanical systems and process-engineering systems (thermodynamics, data on chemical media, valves, pumps, reactors, distillation columns, etc.)
- Design and organization of a simulator
- Sequential-modular simulation
- Dynamic simulation
- Introduction to UniSim
- Process industry applications

b) Modelling and Simulation of Discrete Event Systems

- Specifications of discrete event systems
- Compositional modelling of discrete event systems
- Object-oriented simulation of discrete event systems
- Introduction to Arena and Plant Simulation (formerly Simple ++, eM-Plant)
- Probability distribution
- Queuing theory
- Process and production industry application examples

c) Data-driven Modelling and Model Optimization

- Data from real-world problems (industry, economy, science)
- Data preparation
- Linear regression, logistic regression
- Hypothesis testing
- Classification, Linear discriminant analysis
- Tree-based methods
- Sequential parameter optimization (SPO)
- Model selection
- Treatment of missing values and huge data sets
- Data visualization

- Data mining, CRISP-DM Process
 - Learning, especially advanced modelling techniques: Bootstrap, bagging, meta learner (e.g. random forests), empirical learning problems
 - Evaluation of modelling results (e.g., error measures, overfitting, cross validation, precision and recall)
- d) Modelling and Simulation of Electrical Energy Systems
- System requirements
 - Electrical grids and grid components
 - Grid operation
 - Transmission line theory
 - Stability aspects
 - Network planning
 - Network simulation
 - Distributed energy resources
 - Smart grids
 - Power quality
 - Asset management

Lehr- und Lernmethoden

Lecture, Tutorial, Laboratory Course, Team Project

Empfohlene Literatur

- Stoer, J., et.al.: Introduction to numerical analysis. ISBN 0-387-95452-X
- Kincaid, D., et.al.: Numerical analysis. ISBN 0-534-38905-8
- Brenan, K., et.al.: Numerical solution of initial value problems in differential algebraic equations, 99 TLS 1067, ISBN 0-444-01511-6
- UniSim-Dokumentation, Honeywell 2006
- Kelton, W.D., Sadowski, R.P., Sadowski, D.A.: Simulation with Arena. McCraw-Hill 2002
- Banks, J.: Discrete-Event System Simulation, Prentice-Hall, 1996
- Liebl: Simulation. 2nd revision, Munich. Oldenbourg 1995
- Greasley A.: Simulation Modelling for Business. Ashgate Hants 2004.
- Feldmann K., Reinhardt G. (Hrsg.): Simulationsbasierte Planungssysteme für Organisation und Produktion. Springer Berlin 1999.
- Fishman G.S.: Discrete-Event Simulation. Springer Series in Operations Research. Springer 2001.
- Kelton, W.D., Sadowski, R.P., Sadowski, D.A.: Simulation with Arena. McGraw-Hill 2002
- Witten, I. H., Frank, E.: Data Mining, Hanser, 2nd ed., 2005.
- Hastie, T., Tibshirani, R., Friedman, J.: The Elements of Statistical Learning. Springer, 2001.
- James, G., Witten, D., Hastie, T., and Tibshirani, R.: An Introduction to Statistical Learning with Applications in R. Springer, 4th edition, 2014.
- Law, A.M., Kelton, W.D.: Simulation Modeling and Analysis. McGraw-Hill, Boston. 2000.
- Bartz-Beielstein, T. et al.: Experimental Methods for the Analysis of Optimization Algorithms. Springer, 2010.
- Williams, G.: Data Mining with Rattle and R: The Art of Excavating Data for KnowledgeDiscovery. Springer, New York, 2011.
- Schwab, A. J.: Elektroenergiesysteme, Springer, 2006
- B. Buchholz, Z. Styczynski: Smart Grids, VDE Verlag, 2. Auflage 2018
- Oeding, D., Oswald, B. R.: Elektrische Kraftwerke und Netze, Springer Vieweg, 2016

- Quaschnig, V.: Regenerative Energiesysteme, Hanser Verlag, 6. Auflage 2009
- Handschin, E.: Elektrische Energieübertragungssysteme, Hüthigverlag, 1992
- Heuck, K., Dettmann, K., Schulz, D.: Elektrische Energieversorgung, Springer, 2013
- Marenbach, R., et al.: Elektrische Energietechnik, Springer Vieweg, 2013
- Nelles, D.: Elektrische Energietechnik, Springer, 1998

Prüfungsformen	Mündliche Prüfung Projektarbeit Klausurarbeit
Workload	450 h
Präsenzzeit	200 h (200 h Vorlesung)
Selbststudium	250 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1)
Besonderheiten	Weighting factors for finale module marking: $(((((4 * a) + 2 * b) + 5 * c) + 4 * d)) / 15$
Letzte Aktualisierung am	25.09.2026

1.5.1 Data-Driven Modelling and Model Optimization

Modulnummer	DDMMO
Modulbezeichnung	Data-Driven Modelling and Model Optimization
Art des Moduls	Teilmodul von Modelling and Simulation of Technical Systems
ECTS credits	5
Sprache	Englisch
Dauer des Moduls	2 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Winter- und Sommersemester
Modulverantwortliche*r	Prof. Dr. Thomas Bartz-Beielstein (F10) Prof. Dr. Rainer Scheuring (F10)
Dozierende	Prof. Dr. Thomas Bartz-Beielstein (F10)

Learning Outcome

Students can

- model and simulate continuous systems
- model and simulate discrete event systems
- model data based systems (big data)
- model and simulate electrical energy systems

by

- understanding and applying the concepts of modelling of continuous systems, discrete event systems, data based systems, and electrical energy systems
- understanding the concepts of continuous and discrete event simulators
- evaluating advantages and disadvantages of numerical integration methods
- applying modelling and simulation concepts to real-world technical problems
- designing simulation models of technical systems
- evaluating the quality of the simulation models
- performing simulation experiments
- using tools from statistical learning for modeling and understanding complex data sets
- applying standardized processes (e.g., the CRISP-DM process) to investigate complex data
- summarizing results in reports
- presenting results in oral presentations

to

- develop a deep understanding of the behavior of technical systems
- analyze and understand data from these systems
- be able to carry out design tasks such as system or plant design, controller design, etc. with the aid of simulation tools
- be qualified for a professional career as automation engineer

Modulinhalte

- Data from real-world problems (industry, economy, science)

- Data preparation
- Linear regression, logistic regression
- Hypothesis testing
- Classification, Linear discriminant analysis
- Tree-based methods
- Sequential parameter optimization (SPO)
- Model selection
- Treatment of missing values and huge data sets
- Data visualization
- Data mining, CRISP-DM Process
- Learning, especially advanced modelling techniques: Bootstrap, bagging, meta learner (e.g. random forests), empirical learning problems
- Evaluation of modelling results (e.g., error measures, overfitting, cross validation, precision and recall)

Lehr- und Lernmethoden

Lecture, Tutorial, Laboratory Course, Team Project

Empfohlene Literatur

- Stoer, J., et.al.: Introduction to numerical analysis. ISBN 0-387-95452-X
- Kincaid, D., et.al.: Numerical analysis. ISBN 0-534-38905-8
- Brenan, K., et.al.: Numerical solution of initial value problems in differential algebraic equations, 99 TLS 1067, ISBN 0-444-01511-6
- UniSim-Dokumentation, Honeywell 2006
- Kelton, W.D., Sadowski, R.P., Sadowski, D.A.: Simulation with Arena. McGraw-Hill 2002
- Banks, J.: Discrete-Event System Simulation, Prentice-Hall, 1996
- Liebl: Simulation. 2nd revision, Munich. Oldenbourg 1995
- Greasley A.: Simulation Modelling for Business. Ashgate Hants 2004.
- Feldmann K., Reinhardt G. (Hrsg.): Simulationsbasierte Planungssysteme für Organisation und Produktion. Springer Berlin 1999.
- Fishman G.S.: Discrete-Event Simulation. Springer Series in Operations Research. Springer 2001.
- Kelton, W.D., Sadowski, R.P., Sadowski, D.A.: Simulation with Arena. McGraw-Hill 2002
- Witten, I. H., Frank, E.: Data Mining, Hanser, 2nd ed., 2005.
- Hastie, T., Tibshirani, R., Friedman, J.: The Elements of Statistical Learning. Springer, 2001.
- James, G., Witten, D., Hastie, T., and Tibshirani, R.: An Introduction to Statistical Learning with Applications in R. Springer, 4th edition, 2014.
- Law, A.M., Kelton, W.D.: Simulation Modeling and Analysis. McGraw-Hill, Boston. 2000.
- Bartz-Beielstein, T. et al.: Experimental Methods for the Analysis of Optimization Algorithms. Springer, 2010.
- Williams, G.: Data Mining with Rattle and R: The Art of Excavating Data for KnowledgeDiscovery. Springer, New York, 2011.
- Schwab, A. J.: Elektroenergiesysteme, Springer, 2006
- B. Buchholz, Z. Styczynski: Smart Grids, VDE Verlag, 2. Auflage 2018
- Oeding, D., Oswald, B. R.: Elektrische Kraftwerke und Netze, Springer Vieweg, 2016
- Quaschnig, V.: Regenerative Energiesysteme, Hanser Verlag, 6. Auflage 2009
- Handschin, E.: Elektrische Energieübertragungssysteme, Hüthigverlag, 1992
- Heuck, K., Dettmann, K., Schulz, D.: Elektrische Energieversorgung, Springer, 2013
- Marenbach, R., et al.: Elektrische Energietechnik, Springer Vieweg, 2013

- Nelles, D.: Elektrische Energietechnik, Springer, 1998

Prüfungsformen	Mündliche Prüfung Projektarbeit Klausurarbeit
Workload	150 h
Präsenzzeit	0 h
Selbststudium	150 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1)
Besonderheiten	Keine
Letzte Aktualisierung am	25.09.2026

1.5.2 Modelling and Simulation of Continuous Systems

Modulnummer	MSCS
Modulbezeichnung	Modelling and Simulation of Continuous Systems
Art des Moduls	Teilmodul von Modelling and Simulation of Technical Systems
ECTS credits	4
Sprache	Englisch
Dauer des Moduls	1 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Winter- und Sommersemester
Modulverantwortliche*r	Prof. Dr. Rainer Scheuring (F10)
Dozierende	Prof. Dr. Rainer Scheuring (F10)

Learning Outcome

Students can

- model and simulate continuous systems
- model and simulate discrete event systems
- model data based systems (big data)
- model and simulate electrical energy systems

by

- understanding and applying the concepts of modelling of continuous systems, discrete event systems, data based systems, and electrical energy systems
- understanding the concepts of continuous and discrete event simulators
- evaluating advantages and disadvantages of numerical integration methods
- applying modelling and simulation concepts to real-world technical problems
- designing simulation models of technical systems
- evaluating the quality of the simulation models
- performing simulation experiments
- using tools from statistical learning for modeling and understanding complex data sets
- applying standardized processes (e.g., the CRISP-DM process) to investigate complex data
- summarizing results in reports
- presenting results in oral presentations

to

- develop a deep understanding of the behavior of technical systems
- analyze and understand data from these systems
- be able to carry out design tasks such as system or plant design, controller design, etc. with the aid of simulation tools
- be qualified for a professional career as automation engineer

Modulinhalte

- a) Modelling and Simulation of Continuous Systems

- Modelling mechanical systems and process-engineering systems (thermodynamics, data on chemical media, valves, pumps, reactors, distillation columns, etc.)
- Design and organization of a simulator
- Sequential-modular simulation
- Dynamic simulation
- Introduction to UniSim
- Process industry applications

Lehr- und Lernmethoden

Lecture, Tutorial, Laboratory Course, Team Project

Empfohlene Literatur

- Stoer, J., et.al.: Introduction to numerical analysis. ISBN 0-387-95452-X
- Kincaid, D., et.al.: Numerical analysis. ISBN 0-534-38905-8
- Brenan, K., et.al.: Numerical solution of initial value problems in differential algebraic equations, 99 TLS 1067, ISBN 0-444-01511-6
- UniSim-Dokumentation, Honeywell 2006
- Kelton, W.D., Sadowski, R.P., Sadowski, D.A.: Simulation with Arena. McGraw-Hill 2002
- Banks, J.: Discrete-Event System Simulation, Prentice-Hall, 1996
- Liebl: Simulation. 2nd revision, Munich. Oldenbourg 1995
- Greasley A.: Simulation Modelling for Business. Ashgate Hants 2004.
- Feldmann K., Reinhardt G. (Hrsg.): Simulationsbasierte Planungssysteme für Organisation und Produktion. Springer Berlin 1999.
- Fishman G.S.: Discrete-Event Simulation. Springer Series in Operations Research. Springer 2001.
- Kelton, W.D., Sadowski, R.P., Sadowski, D.A.: Simulation with Arena. McGraw-Hill 2002
- Witten, I. H., Frank, E.: Data Mining, Hanser, 2nd ed., 2005.
- Hastie, T., Tibshirani, R., Friedman, J.: The Elements of Statistical Learning. Springer, 2001.
- James, G., Witten, D., Hastie, T., and Tibshirani, R.: An Introduction to Statistical Learning with Applications in R. Springer, 4th edition, 2014.
- Law, A.M., Kelton, W.D.: Simulation Modeling and Analysis. McGraw-Hill, Boston. 2000.
- Bartz-Beielstein, T. et al.: Experimental Methods for the Analysis of Optimization Algorithms. Springer, 2010.
- Williams, G.: Data Mining with Rattle and R: The Art of Excavating Data for KnowledgeDiscovery. Springer, New York, 2011.
- Schwab, A. J.: Elektroenergiesysteme, Springer, 2006
- B. Buchholz, Z. Styczynski: Smart Grids, VDE Verlag, 2. Auflage 2018
- Oeding, D., Oswald, B. R.: Elektrische Kraftwerke und Netze, Springer Vieweg, 2016
- Quaschnig, V.: Regenerative Energiesysteme, Hanser Verlag, 6. Auflage 2009
- Handschin, E.: Elektrische Energieübertragungssysteme, Hüthigverlag, 1992
- Heuck, K., Dettmann, K., Schulz, D.: Elektrische Energieversorgung, Springer, 2013
- Marenbach, R., et al.: Elektrische Energietechnik, Springer Vieweg, 2013
- Nelles, D.: Elektrische Energietechnik, Springer, 1998

Prüfungsformen

Mündliche Prüfung
Projektarbeit
Klausurarbeit

Workload	120 h
Präsenzzeit	0 h
Selbststudium	120 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1)
Besonderheiten	Keine
Letzte Aktualisierung am	25.09.2026

1.5.3 Modelling and Simulation of Discrete Event Systems

Modulnummer	MSDES
Modulbezeichnung	Modelling and Simulation of Discrete Event Systems
Art des Moduls	Teilmodul von Modelling and Simulation of Technical Systems
ECTS credits	15
Sprache	Englisch
Dauer des Moduls	2 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Winter- und Sommersemester
Modulverantwortliche*r	Prof. Dr. Rainer Scheuring (F10)
Dozierende	Prof. Dr. Rainer Scheuring (F10)

Learning Outcome

Students can

- model and simulate continuous systems
- model and simulate discrete event systems
- model data based systems (big data)
- model and simulate electrical energy systems

by

- understanding and applying the concepts of modelling of continuous systems, discrete event systems, data based systems, and electrical energy systems
- understanding the concepts of continuous and discrete event simulators
- evaluating advantages and disadvantages of numerical integration methods
- applying modelling and simulation concepts to real-world technical problems
- designing simulation models of technical systems
- evaluating the quality of the simulation models
- performing simulation experiments
- using tools from statistical learning for modeling and understanding complex data sets
- applying standardized processes (e.g., the CRISP-DM process) to investigate complex data
- summarizing results in reports
- presenting results in oral presentations

to

- develop a deep understanding of the behavior of technical systems
- analyze and understand data from these systems
- be able to carry out design tasks such as system or plant design, controller design, etc. with the aid of simulation tools
- be qualified for a professional career as automation engineer

Modulinhalte

- Specifications of discrete event systems
- Compositional modelling of discrete event systems

- Object-oriented simulation of discrete event systems
- Introduction to Arena and Plant Simulation (formerly Simple ++, eM-Plant)
- Probability distribution
- Queuing theory
- Process and production industry application examples

Lehr- und Lernmethoden

Lecture, Tutorial, Laboratory Course, Team Project

Empfohlene Literatur

- Stoer, J., et.al.: Introduction to numerical analysis. ISBN 0-387-95452-X
- Kincaid, D., et.al.: Numerical analysis. ISBN 0-534-38905-8
- Brenan, K., et.al.: Numerical solution of initial value problems in differential algebraic equations, 99 TLS 1067, ISBN 0-444-01511-6
- UniSim-Dokumentation, Honeywell 2006
- Kelton, W.D., Sadowski, R.P., Sadowski, D.A.: Simulation with Arena. McGraw-Hill 2002
- Banks, J.: Discrete-Event System Simulation, Prentice-Hall, 1996
- Liebl: Simulation. 2nd revision, Munich. Oldenbourg 1995
- Greasley A.: Simulation Modelling for Business. Ashgate Hants 2004.
- Feldmann K., Reinhardt G. (Hrsg.): Simulationsbasierte Planungssysteme für Organisation und Produktion. Springer Berlin 1999.
- Fishman G.S.: Discrete-Event Simulation. Springer Series in Operations Research. Springer 2001.
- Kelton, W.D., Sadowski, R.P., Sadowski, D.A.: Simulation with Arena. McGraw-Hill 2002
- Witten, I. H., Frank, E.: Data Mining, Hanser, 2nd ed., 2005.
- Hastie, T., Tibshirani, R., Friedman, J.: The Elements of Statistical Learning. Springer, 2001.
- James, G., Witten, D., Hastie, T., and Tibshirani, R.: An Introduction to Statistical Learning with Applications in R. Springer, 4th edition, 2014.
- Law, A.M., Kelton, W.D.: Simulation Modeling and Analysis. McGraw-Hill, Boston. 2000.
- Bartz-Beielstein, T. et al.: Experimental Methods for the Analysis of Optimization Algorithms. Springer, 2010.
- Williams, G.: Data Mining with Rattle and R: The Art of Excavating Data for KnowledgeDiscovery. Springer, New York, 2011.
- Schwab, A. J.: Elektroenergiesysteme, Springer, 2006
- B. Buchholz, Z. Styczynski: Smart Grids, VDE Verlag, 2. Auflage 2018
- Oeding, D., Oswald, B. R.: Elektrische Kraftwerke und Netze, Springer Vieweg, 2016
- Quaschnig, V.: Regenerative Energiesysteme, Hanser Verlag, 6. Auflage 2009
- Handschin, E.: Elektrische Energieübertragungssysteme, Hüthigverlag, 1992
- Heuck, K., Dettmann, K., Schulz, D.: Elektrische Energieversorgung, Springer, 2013
- Marenbach, R., et al.: Elektrische Energietechnik, Springer Vieweg, 2013
- Nelles, D.: Elektrische Energietechnik, Springer, 1998

Prüfungsformen	Mündliche Prüfung Projektarbeit Klausurarbeit
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Workload	450 h
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Präsenzzeit	0 h
Selbststudium	450 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1)
Besonderheiten	Keine
Letzte Aktualisierung am	25.09.2026

1.5.4 Modelling and Simulation of Electrical Energy Systems

Modulnummer	MS-01
Modulbezeichnung	Modelling and Simulation of Electrical Energy Systems
Art des Moduls	Teilmodul von Modelling and Simulation of Technical Systems
ECTS credits	4
Sprache	Englisch
Dauer des Moduls	1 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Winter- und Sommersemester
Modulverantwortliche*r	Prof. Dr. Michael Freiburg (F10) Prof. Dr. Rainer Scheuring (F10)
Dozierende	Prof. Dr. Michael Freiburg (F10)

Learning Outcome

Students can

- model and simulate continuous systems
- model and simulate discrete event systems
- model data based systems (big data)
- model and simulate electrical energy systems

by

- understanding and applying the concepts of modelling of continuous systems, discrete event systems, data based systems, and electrical energy systems
- understanding the concepts of continuous and discrete event simulators
- evaluating advantages and disadvantages of numerical integration methods
- applying modelling and simulation concepts to real-world technical problems
- designing simulation models of technical systems
- evaluating the quality of the simulation models
- performing simulation experiments
- using tools from statistical learning for modeling and understanding complex data sets
- applying standardized processes (e.g., the CRISP-DM process) to investigate complex data
- summarizing results in reports
- presenting results in oral presentations

to

- develop a deep understanding of the behavior of technical systems
- analyze and understand data from these systems
- be able to carry out design tasks such as system or plant design, controller design, etc. with the aid of simulation tools
- be qualified for a professional career as automation engineer

Modulinhalte

- System requirements

- Electrical grids and grid components
- Grid operation
 - Transmission line theory
 - Stability aspects
 - Network planning
 - Network simulation
- Distributed energy resources
- Smart grids
- Power quality
- Asset management

Lehr- und Lernmethoden

Lecture, Tutorial, Laboratory Course, Team Project

Empfohlene Literatur

- Stoer, J., et.al.: Introduction to numerical analysis. ISBN 0-387-95452-X
 - Kincaid, D., et.al.: Numerical analysis. ISBN 0-534-38905-8
 - Brenan, K., et.al.: Numerical solution of initial value problems in differential algebraic equations, 99 TLS 1067, ISBN 0-444-01511-6
 - UniSim-Dokumentation, Honeywell 2006
 - Kelton, W.D., Sadowski, R.P., Sadowski, D.A.: Simulation with Arena. McCraw-Hill 2002
 - Banks, J.: Discrete-Event System Simulation, Prentice-Hall, 1996
 - Liebl: Simulation. 2nd revision, Munich. Oldenbourg 1995
 - Greasley A.: Simulation Modelling for Business. Ashgate Hants 2004.
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 - Witten, I. H., Frank, E.: Data Mining, Hanser, 2nd ed., 2005.
 - Hastie, T., Tibshirani, R., Friedman, J.: The Elements of Statistical Learning. Springer, 2001.
 - James, G., Witten, D., Hastie, T., and Tibshirani, R.: An Introduction to Statistical Learning with Applications in R. Springer, 4th edition, 2014.
 - Law, A.M., Kelton, W.D.: Simulation Modeling and Analysis. McGraw-Hill, Boston. 2000.
 - Bartz-Beielstein, T. et al.: Experimental Methods for the Analysis of Optimization Algorithms. Springer, 2010.
 - Williams, G.: Data Mining with Rattle and R: The Art of Excavating Data for KnowledgeDiscovery. Springer, New York, 2011.
 - Schwab, A. J.: Elektroenergiesysteme, Springer, 2006
 - B. Buchholz, Z. Styczynski: Smart Grids, VDE Verlag, 2. Auflage 2018
 - Oeding, D., Oswald, B. R.: Elektrische Kraftwerke und Netze, Springer Vieweg, 2016
 - Quaschnig, V.: Regenerative Energiesysteme, Hanser Verlag, 6. Auflage 2009
 - Handschin, E.: Elektrische Energieübertragungssysteme, Hüthigverlag, 1992
 - Heuck, K., Dettmann, K., Schulz, D.: Elektrische Energieversorgung, Springer, 2013
 - Marenbach, R., et al.: Elektrische Energietechnik, Springer Vieweg, 2013
 - Nelles, D.: Elektrische Energietechnik, Springer, 1998
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Prüfungsformen	Mündliche Prüfung Projektarbeit Klausurarbeit
Workload	120 h
Präsenzzeit	0 h
Selbststudium	120 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Automation & IT PO-4 (Sem. 1)
Besonderheiten	Keine
Letzte Aktualisierung am	25.09.2026

1.6 Optimization of Technical Systems

Modulnummer	OS-01
Modulbezeichnung	Optimization of Technical Systems
Art des Moduls	Obermodul von Machine Learning and AI, Numerical Methods, Optimization
ECTS credits	10
Sprache	Englisch
Dauer des Moduls	2 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Wintersemester
Modulverantwortliche*r	Prof. Dr. Thomas Bartz-Beielstein (F10)
Dozierende	Prof. Dr. Thomas Bartz-Beielstein (F10) Prof. Dr. Boris Naujoks (F10)

Learning Outcome

Students can

- optimize technical systems
- implement, train and debug neural networks
- judge the importance of human-centered AI
- consider fairness, transparency, and ethics in AI

by

- understanding, applying and evaluating numerical methods and algorithms
- understanding and applying optimization theory
- understanding and applying machine learning and artificial intelligence methods and algorithms
- analyzing new tasks and problems
- choosing suitable optimization methods
- using “state of the art” optimization software and optimization algorithms
- implementing representations, image features
- applying optimization algorithms (stochastic gradient descent)
- understanding backpropagation
- choosing suitable network architectures
- analyzing generative models
- ascertaining and evaluation correct solutions
- understanding bias in data
- using tools for visualizing model states

- summarizing results in reports
- presenting results in oral presentations

to

- be able to improve the behavior of technical systems
- solve practical engineering tasks in classification and prediction
- be qualified for a professional career as automation engineer

Modulinhalte

Lectures:

- a) Numerical Methods
- b) Optimization
- c) Machine Learning and AI

Lecturer:

- a) Prof. Dr. Thomas Bartz-Beielstein, Prof. Dr. Boris Naujoks
- b) Prof. Dr. Thomas Bartz-Beielstein, Prof. Dr. Boris Naujoks
- c) Prof. Dr. Thomas Bartz-Beielstein

Credit Points:

- a) 3 CP
- b) 4 CP
- c) 3 CP

Content:

a) Numerical Methods

- Matrices
- Differences, Derivatives, and Boundary Conditions
- Inverses and Delta Functions
- Eigenvalues and Eigenvectors
- Positive Definite Matrices
- Numerical Linear Algebra: LU, QR, SVD
- Numerical integration of standard differential equation systems (linear, non-linear, formal procedures (Runge-Kutta etc.)
- Boundary value problems
- Differential Equations of Equilibrium
- Cubic Splines and Fourth Order Equations
- Gradient and Divergence
- Laplace's Equation
- Finite Differences and Fast Poisson Solvers
- The Finite Element Method
- Stochastic simulation
- Design and organisation of a Monte Carlo simulator

b) Optimization

- Optimization criteria
- Optimization basics (calculus of variation, Euler formula, Hamilton formula, maximum-principle, etc.)
- Linear Programming (LP)

- Nonlinear Programming (NLP)
- Quadratic Programming (QP)
- Integer Programming (IP)
- Direct (extrapolation-free) searching procedures (pattern search)
- Stochastic procedures (simulated annealing, evolutionary algorithms)
- Application of optimization procedures to practical problems

c) Machine Learning and AI

- Image Classification: Data-driven Approach, k-Nearest Neighbor, train/val/test splits, L1/L2 distances, cross-validation
- Linear Regression, Logistic Regression, Softmax Regression
- Optimization: Stochastic Gradient Descent
- Neural Networks, Backpropagation
- Convolutional Neural Networks: Architectures, Convolution / Pooling Layers
- Understanding and Visualizing Convolutional Neural Networks

Lehr- und Lernmethoden

Lecture, Tutorial, Laboratory Course

Empfohlene Literatur

- Stoer, J., et.al.: Introduction to numerical analysis. ISBN 0-387-95452-X
- Kincaid, D., et.al.: Numerical analysis. ISBN 0-534-38905-8
- Gill, P.E., Murray, W., Wright, M.: Practical Optimization. Academic Press, London, 1989
- Edgar, T.F., Himmelblau, D.M.: Optimization of chemical processes. Mc Graw-Hill, 2001
- Gekeler, E.W.: Mathematical Methods for Mechanics with MATLAB Experiments. Springer, Berlin 2008
- Neumann, K. und Morlock, M: Operations Research. 2. Aufl. Hanser, München 2002
- Bartz-Beielstein, T.: Experimental Research in Evolutionary Computation. 1.Aufl., Springer, Berlin 2006
- Markon, S., Kita, H., Kise, H., Bartz-Beielstein, T.: Modern Supervisory and Optimal Control with Applications in the Control of Passenger Traffic Systems in Buildings. Springer, Berlin, Heidelberg, New York, 2006
- Nelli, F.: Python Data Analytics, Springer. 2015
- Moncecchi, G., Garreta, R.: Learning scikit-learn - Machine Learning in Python. 2013
- Goodfellow, I., Bengio, Y., and Courville, A.: Deep Learning. MIT press, 2016

Prüfungsformen	Mündliche Prüfung Lernportfolio Klausurarbeit
Workload	300 h
Präsenzzeit	120 h (120 h Vorlesung)
Selbststudium	180 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine

Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Keine
Besonderheiten	Weighting factors for finale module marking: $(3 * a) + 4 * b + 3 * c) / 10$
Letzte Aktualisierung am	25.09.2026

1.6.1 Machine Learning and AI

Modulnummer	OPTMLAI
Modulbezeichnung	Machine Learning and AI
Art des Moduls	Teilmodul von Optimization of Technical Systems
ECTS credits	4
Sprache	Englisch
Dauer des Moduls	1 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Sommersemester
Modulverantwortliche*r	Prof. Dr. Thomas Bartz-Beielstein (F10)
Dozierende	Prof. Dr. Thomas Bartz-Beielstein (F10)

Learning Outcome

Students can

- optimize technical systems
- implement, train and debug neural networks
- judge the importance of human-centered AI
- consider fairness, transparency, and ethics in AI

by

- understanding, applying and evaluating numerical methods and algorithms
- understanding and applying optimization theory
- understanding and applying machine learning and artificial intelligence methods and algorithms
- analyzing new tasks and problems
- choosing suitable optimization methods
- using “state of the art” optimization software and optimization algorithms
- implementing representations, image features
- applying optimization algorithms (stochastic gradient descent)
- understanding backpropagation
- choosing suitable network architectures
- analyzing generative models
- ascertaining and evaluation correct solutions
- understanding bias in data
- using tools for visualizing model states
- summarizing results in reports
- presenting results in oral presentations

to

- be able to improve the behavior of technical systems
- solve practical engineering tasks in classification and prediction
- be qualified for a professional career as automation engineer

Modulinhalte

Lectures: Machine Learning and AI

- Image Classification: Data-driven Approach, k-Nearest Neighbor, train/val/test splits, L1/L2 distances, cross-validation
- Linear Regression, Logistic Regression, Softmax Regression
- Optimization: Stochastic Gradient Descent
- Neural Networks, Backpropagation
- Convolutional Neural Networks: Architectures, Convolution / Pooling Layers
- Understanding and Visualizing Convolutional Neural Networks

Lehr- und Lernmethoden

Lecture, Tutorial, Laboratory Course

Empfohlene Literatur

- Stoer, J., et.al.: Introduction to numerical analysis. ISBN 0-387-95452-X
- Kincaid, D., et.al.: Numerical analysis. ISBN 0-534-38905-8
- Gill, P.E., Murray, W., Wright, M.: Practical Optimization. Academic Press, London, 1989
- Edgar, T.F., Himmelblau, D.M.: Optimization of chemical processes. Mc Graw-Hill, 2001
- Gekeler, E.W.: Mathematical Methods for Mechanics with MATLAB Experiments. Springer, Berlin 2008
- Neumann, K. und Morlock, M: Operations Research. 2. Aufl. Hanser, München 2002
- Bartz-Beielstein, T.: Experimental Research in Evolutionary Computation. 1.Aufl., Springer, Berlin 2006
- Markon, S., Kita, H., Kise, H., Bartz-Beielstein, T.: Modern Supervisory and Optimal Control with Applications in the Control of Passenger Traffic Systems in Buildings. Springer, Berlin, Heidelberg, New York, 2006
- Nelli, F.: Python Data Analytics, Springer. 2015
- Moncecchi, G., Garreta, R.: Learning scikit-learn - Machine Learning in Python. 2013
- Goodfellow, I., Bengio, Y., and Courville, A.: Deep Learning. MIT press, 2016

Prüfungsformen	Mündliche Prüfung Lernportfolio Klausurarbeit
Workload	120 h
Präsenzzeit	120 h (120 h Vorlesung)
Selbststudium	Keine
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine

Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Keine
Besonderheiten	Keine
Letzte Aktualisierung am	25.09.2026

1.6.2 Numerical Methods

Modulnummer	OPTNM
Modulbezeichnung	Numerical Methods
Art des Moduls	Teilmodul von Optimization of Technical Systems
ECTS credits	3
Sprache	Englisch
Dauer des Moduls	1 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Wintersemester
Modulverantwortliche*r	Prof. Dr. Thomas Bartz-Beielstein (F10)
Dozierende	Prof. Dr. Thomas Bartz-Beielstein (F10) Prof. Dr. Boris Naujoks (F10)

Learning Outcome

Students can

- optimize technical systems
- implement, train and debug neural networks
- judge the importance of human-centered AI
- consider fairness, transparency, and ethics in AI

by

- understanding, applying and evaluating numerical methods and algorithms
- understanding and applying optimization theory
- understanding and applying machine learning and artificial intelligence methods and algorithms
- analyzing new tasks and problems
- choosing suitable optimization methods
- using “state of the art” optimization software and optimization algorithms
- implementing representations, image features
- applying optimization algorithms (stochastic gradient descent)
- understanding backpropagation
- choosing suitable network architectures
- analyzing generative models
- ascertaining and evaluation correct solutions
- understanding bias in data
- using tools for visualizing model states
- summarizing results in reports

- presenting results in oral presentations

to

- be able to improve the behavior of technical systems
- solve practical engineering tasks in classification and prediction
- be qualified for a professional career as automation engineer

Modulinhalte

- Matrices
- Differences, Derivatives, and Boundary Conditions
- Inverses and Delta Functions
- Eigenvalues and Eigenvectors
- Positive Definite Matrices
- Numerical Linear Algebra: LU, QR, SVD
- Numerical integration of standard differential equation systems (linear, non-linear, formal procedures (Runge-Kutta etc.)
- Boundary value problems
- Differential Equations of Equilibrium
- Cubic Splines and Fourth Order Equations
- Gradient and Divergence
- Laplace's Equation
- Finite Differences and Fast Poisson Solvers
- The Finite Element Method
- Stochastic simulation
- Design and organisation of a Monte Carlo simulator

Lehr- und Lernmethoden

Lecture, Tutorial, Laboratory Course

Empfohlene Literatur

- Stoer, J., et.al.: Introduction to numerical analysis. ISBN 0-387-95452-X
 - Kincaid, D., et.al.: Numerical analysis. ISBN 0-534-38905-8
 - Gill, P.E., Murray, W., Wright, M.: Practical Optimization. Academic Press, London, 1989
 - Edgar, T.F., Himmelblau, D.M.: Optimization of chemical processes. Mc Graw-Hill, 2001
 - Gekeler, E.W.: Mathematical Methods for Mechanics with MATLAB Experiments. Springer, Berlin 2008
 - Neumann, K. und Morlock, M.: Operations Research. 2. Aufl. Hanser, München 2002
 - Bartz-Beielstein, T.: Experimental Research in Evolutionary Computation. 1.Aufl., Springer, Berlin 2006
 - Markon, S., Kita, H., Kise, H., Bartz-Beielstein, T.: Modern Supervisory and Optimal Control with Applications in the Control of Passenger Traffic Systems in Buildings. Springer, Berlin, Heidelberg, New York, 2006
 - Nelli, F.: Python Data Analytics, Springer. 2015
 - Moncecchi, G., Garreta, R.: Learning scikit-learn - Machine Learning in Python. 2013
 - Goodfellow, I., Bengio, Y., and Courville, A.: Deep Learning. MIT press, 2016
-

Prüfungsformen	Mündliche Prüfung Lernportfolio Klausurarbeit
Workload	90 h
Präsenzzeit	90 h (90 h Vorlesung)
Selbststudium	Keine
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Keine
Besonderheiten	Keine
Letzte Aktualisierung am	25.09.2026

1.6.3 Optimization

Modulnummer	OPTOPT
Modulbezeichnung	Optimization
Art des Moduls	Teilmodul von Optimization of Technical Systems
ECTS credits	4
Sprache	Englisch
Dauer des Moduls	1 Semester
Empfohlenes Studiensemester	1. Semester
Häufigkeit des Angebots	Wintersemester
Modulverantwortliche*r	Prof. Dr. Thomas Bartz-Beielstein (F10)
Dozierende	Prof. Dr. Thomas Bartz-Beielstein (F10) Prof. Dr. Boris Naujoks (F10)

Learning Outcome

Students can

- optimize technical systems
- implement, train and debug neural networks
- judge the importance of human-centered AI
- consider fairness, transparency, and ethics in AI

by

- understanding, applying and evaluating numerical methods and algorithms
- understanding and applying optimization theory
- understanding and applying machine learning and artificial intelligence methods and algorithms
- analyzing new tasks and problems
- choosing suitable optimization methods
- using “state of the art” optimization software and optimization algorithms
- implementing representations, image features
- applying optimization algorithms (stochastic gradient descent)
- understanding backpropagation
- choosing suitable network architectures
- analyzing generative models
- ascertaining and evaluation correct solutions
- understanding bias in data
- using tools for visualizing model states
- summarizing results in reports

- presenting results in oral presentations

to

- be able to improve the behavior of technical systems
- solve practical engineering tasks in classification and prediction
- be qualified for a professional career as automation engineer

Modulinhalte

Optimization

- Optimization criteria
- Optimization basics (calculus of variation, Euler formula, Hamilton formula, maximum-principle, etc.)
- Linear Programming (LP)
- Nonlinear Programming (NLP)
- Quadratic Programming (QP)
- Integer Programming (IP)
- Direct (extrapolation-free) searching procedures (pattern search)
- Stochastic procedures (simulated annealing, evolutionary algorithms)
- Application of optimization procedures to practical problems

Lehr- und Lernmethoden

Lecture, Tutorial, Laboratory Course

Empfohlene Literatur

- Stoer, J., et.al.: Introduction to numerical analysis. ISBN 0-387-95452-X
- Kincaid, D., et.al.: Numerical analysis. ISBN 0-534-38905-8
- Gill, P.E., Murray, W., Wright, M.: Practical Optimization. Academic Press, London, 1989
- Edgar, T.F., Himmelblau, D.M.: Optimization of chemical processes. Mc Graw-Hill, 2001
- Gekeler, E.W.: Mathematical Methods for Mechanics with MATLAB Experiments. Springer, Berlin 2008
- Neumann, K. und Morlock, M: Operations Research. 2. Aufl. Hanser, München 2002
- Bartz-Beielstein, T.: Experimental Research in Evolutionary Computation. 1.Aufl., Springer, Berlin 2006
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- Nelli, F.: Python Data Analytics, Springer. 2015
- Moncecchi, G., Garreta, R.: Learning scikit-learn - Machine Learning in Python. 2013
- Goodfellow, I., Bengio, Y., and Courville, A.: Deep Learning. MIT press, 2016

Prüfungsformen	Mündliche Prüfung Lernportfolio Klausurarbeit
Workload	120 h
Präsenzzeit	120 h (120 h Vorlesung)

Selbststudium	Keine
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Keine
Besonderheiten	Keine
Letzte Aktualisierung am	25.09.2026

1.7 Case Studies

Modulnummer	CS-01
Modulbezeichnung	Case Studies
Art des Moduls	Pflichtmodul
ECTS credits	30
Sprache	Englisch
Dauer des Moduls	1 Semester
Empfohlenes Studiensemester	3. Semester
Häufigkeit des Angebots	Wintersemester
Modulverantwortliche*r	Prof. Dr. Rainer Scheuring (F10)
Dozierende	Prof. Dr. Elena Algorri (F10) Prof. Dr. Thomas Bartz-Beielstein (F10) Prof. Dr. Michael Freiburg (F10) Prof. Dr. Felix Hackelöer (F10) Prof. Dr. Rainer Scheuring (F10) Prof. Dr. Christian Wolf (F10) Prof. Dr. Dietlind Zühlke (F10)

Learning Outcome

Students can

- create a case study

by

- understanding the technical or scientific problem
- Identifying relevant previous work in the literature
- developing solution approaches
- evaluating the solution approaches
- selecting and implementing the best approach
- writing a report that describes the methods and the approach used
- presenting the work in a seminar

to

- specialize in a sub-area of the Master's programme
- develop their abilities to solve a technical or scientific problem
- be qualified for a professional career as automation engineer

Modulinhalte

Case Study:

- a) Case Study Industrial Communication and Information Security (ICIS)
- b) Case Study Integration of Technical and Business Information Systems (ITBS)
- c) Case Study Modelling and Simulation of Technical Systems (MSTS)
- d) Case Study Control of Technical Systems (CTS)
- e) Case Study Optimization of Technical Systems (OTS)

Lecturer:

- a) see Lecturers
- b) see Lecturers
- c) see Lecturers
- d) see Lecturers
- e) see Lecturers

Credit Points:

- a) 10 CP
- b) 10 CP
- c) 10 CP
- d) 10 CP
- e) 10 CP

Content of case studies:

The content of a case study is related to the content of the corresponding module of the master program.

Lehr- und Lernmethoden

Team project

Empfohlene Literatur

See other modules

Prüfungsformen	Projektdokumentation (75 %) Schriftliche und mündliche Präsentation der Ergebnisse der Projektarbeit (25 %)
Workload	900 h
Präsenzzeit	100 h (1 h Vorlesung, 99 h Projektbetreuung)
Selbststudium	800 h
Empfohlene Voraussetzungen	Modules and lectures of 1st and 2nd semester
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Keine

Besonderheiten

Case studies have to be processed in teams. Each student has to select three case studies. Each case study has to be from a different category (i.e. a) or b) or c) or d) or e)).

The module examination has two parts: the case study report and the oral presentation. Both parts have to be passed. The oral presentation is included in the grade awarded, whereby the weighting of the case study report to the oral presentation is 3:1.

Weighting factors for finale module marking: Each case study has a weighting factor of 10. $(10 * x) + 10 * y + 10 * z) / 30$

Letzte Aktualisierung am

25.09.2026

1.8 Master Thesis

Modulnummer	MT-01
Modulbezeichnung	Master Thesis
Art des Moduls	Pflichtmodul
ECTS credits	30
Sprache	Englisch
Dauer des Moduls	1 Semester
Empfohlenes Studiensemester	4. Semester
Häufigkeit des Angebots	Winter- und Sommersemester
Modulverantwortliche*r	Prof. Dr. Rainer Scheuring (F10)
Dozierende	Prof. Dr. Elena Algorri (F10) Prof. Dr. Thomas Bartz-Beielstein (F10) Prof. Dr. Michael Freiburg (F10) Prof. Dr. Felix Hackelöer (F10) Prof. Dr. Peter Kern (F10) Prof. Dr. Rainer Scheuring (F10) Prof. Dr. Christian Wolf (F10)

Learning Outcome

A student can

- create a scientific thesis

by

- understanding the technical or scientific problem
- identifying, analyzing and evaluating relevant previous work in available literature
- developing solution approaches
- evaluating the solution approaches
- selecting the best approach
- implementing the best approach
- describing the problem and its solution approaches and the approach used in the form of a written final thesis
- presenting the results in an oral presentation (colloquium)

to

- further develop and demonstrate his or her capacities for independent scientific work
- further develop and demonstrate his or her ability to solve a technical or scientific problem on time
- be qualified for a professional career as automation engineer

Modulinhalte

Lecturer:

See Lecturers

Content:

The content of the master thesis is related to the content of the modules of the Master's programme.

Lehr- und Lernmethoden

- Independent work
- Obligatory and voluntary consultation
- Presentation of interim results
- Presentation of the master's degree thesis

Prüfungsformen	Präsentation (33 %) Schriftliche Ausarbeitung (67 %)
Workload	900 h
Präsenzzeit	60 h (1 h Vorlesung, 59 h Projektbetreuung)
Selbststudium	840 h
Empfohlene Voraussetzungen	Keine
Zwingende Voraussetzungen	Keine
Anwesenheitspflicht	Keine
Prüfungsvorleistung	Keine
Verwendung des Moduls in weiteren Studiengängen	Keine
Besonderheiten	Weighting factors for finale module marking: (20 * Thesis + 10 * Colloquium) / 30
Letzte Aktualisierung am	25.09.2026
