

Technology
Arts Sciences
TH Köln

Faculty of Information, Media and Electrical Engineering

Master Electrical Engineering and Information Technology 2024

Module Manual

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The most recent version of this handbook can be found here:

<https://f07-studieninfo.web.th-koeln.de/mhb/current/en/MaET2024.html>

1. Program Description

The Master of Science in Electrical Engineering and Information Technology is a three-semester course of study that builds consecutively on the Bachelor of Science in Electrical Engineering and Information Technology. It enables students to carry out independent scientific work in the field of electrical engineering. Building on practice-oriented study profiles, the Master's degree course in Electrical Engineering enables students to expand their basic knowledge in a scientifically sound manner and to specialize in a particular field.

Orientation of the degree program

An important first goal of the Master's degree course is to consolidate and deepen the basic knowledge acquired in the Bachelor's degree course. The next step is to specialize in one of the three key disciplines of automation technology, electrical energy technology and optical technologies. In addition, students will learn how to summarize, evaluate and present complex technical processes and systems as well as their economic significance. This is also done in English. The quality assurance of the degree program is carried out by the Standing Committee for Teaching, Studies and Academic Reform at TH Köln.

Occupational fields

Graduates have qualifications that open up a wide range of career opportunities. Without claiming to be exhaustive, hardware and / or software-oriented fields of activity are, for example

- in (electrical) automotive engineering,
- medical technology and biotechnology,
- in the entire consumer goods industry
- in production
- in the chemical industry
- in the area of public supply and infrastructure,
- in the field of energy generation, distribution and supply,
- in environmental protection,
- as well as in the fields of information and communication technologies.

You will be able to make independent scientific contributions in your specialist area and you will be able to familiarize yourself independently with new specialist areas. You are therefore particularly suited to working in research and development departments. Due to your extensive basic knowledge, you may also be able to work in interdisciplinary teams. You will be prepared for management positions in industry as well as positions in the senior civil service of public institutions. Graduates with very good degrees have good prospects of successfully applying for doctoral positions at technical colleges or universities. The specializations in automation technology, electrical power engineering and optical technologies open up a very broad spectrum of professional fields, not only in the electrical engineering industry. Prerequisite for admission to the program is a qualified degree in electrical engineering with a Bachelor of Engineering or Bachelor of Science degree. Proof of qualification should generally be a qualified first degree with 210 ECTS credit points and an overall grade of 2.5 or better (further details can be found in the examination and enrolment regulations). Prospective students with a Bachelor's degree in a related subject area can also apply and may receive admission with conditions.

Study requirements

A qualified degree in electrical engineering with a Bachelor of Engineering or Bachelor of Science degree is a prerequisite for admission to the course. Proof of qualification should generally be a qualified first degree with 210 ECTS credit points and an overall grade of 2.5 or better (further details can be found in the examination and enrolment regulations). Prospective students with a Bachelor's degree in a related subject area can also apply and may receive admission with conditions.

Course of study

The degree program has a modular structure and the modules and courses are assessed according to the European Credit Transfer System (ECTS). This facilitates international student exchange. The course is worth a total of 90 ECTS points. In accordance with the objectives of the Master's degree course in Electrical Engineering and Information Technology, knowledge is imparted in four blocks, each comprising several modules: - Fundamentals (three compulsory modules) - Specialist profiling through three modules in either Automation Technology, Electrical Power Engineering or Optical Technologies - Three further electives - Work in a project context: This includes activities in a project management role, the research seminar with the element of specialist discourse and finally the Master's thesis with colloquium

2. Graduate Profile

Graduates of the M. Sc. Electrical Engineering and Information Technology degree program are able to independently master demanding, interdisciplinary challenges in research, development and management. They design, evaluate and implement complex technical systems at a scientific level. Building on the foundations of the Bachelor's degree, they expand and deepen their skills through research- and project-oriented work in the areas of automation technology, electrical power engineering or optical technologies. They are thus excellently qualified for leading positions in industry, research and public infrastructure as well as for a doctorate.

The aim of the M. Sc. in Electrical Engineering and Information Technology is to build on the broad engineering foundation of the Bachelor's degree and to systematically expand it through scientifically sound specialization, independent research and interdisciplinary skills.

In contrast to the Bachelor's degree course, which focuses on application-oriented basic training, the Master's degree course focuses on the research-based design, evaluation and sustainable management of complex technical systems. Graduates work in an interdisciplinary, systemic and reflective manner - both in the depth of the specialist field and in related scientific and social contexts.

As part of the degree program, graduates develop an individual profile in the following areas:

- They are able to design and simulate technical systems from a scientific point of view and evaluate them in their entirety - taking into account technical, economic and ethical aspects.
- You will be able to plan, manage and carry out interdisciplinary research and development projects, particularly in complex subject areas such as autonomous control, sustainable energy supply or high-tech optical systems.
- They have sound skills in scientific work - including literature work, application of methods, hypothesis formation and critical presentation of results - and are therefore ideally prepared for a doctorate.
- They master modern tools for modeling, simulation, quality assurance and project management and apply these in a targeted manner in innovative development environments.
- Graduates take on responsibility in specialist management roles and actively shape technical and social transformation processes - for example in the energy sector, mobility or medical technology.
- They operate confidently in an international environment and can communicate technical content in German and English in a manner appropriate to the target audience.
- The specialization in one of the key areas of automation technology, electrical energy technology or optical technologies allows a targeted specialization that can be transferred to a wide range of professional fields - from research & development to strategic technology management.

3. Fields of Action

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

Development and Design

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

Research and innovation

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

Leadership and management

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

Quality assurance and testing

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

4. Competencies

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

Development and design of complex systems

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

Testing and evaluation of complex systems

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

Scientific work and research

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

Project management and teamwork

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

Self-organization and self-taught skills

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

Communication and intercultural competence

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

Technical and scientific fundamentals

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

Sustainability and social responsibility

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

Analysis, simulation and abstraction

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

Leadership and decision-making responsibility

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

Applying ethical values and principles in practice

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

Integrative thinking and acting in interdisciplinary teams

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

Innovation and creativity

Developing new solutions and concepts to overcome technical challenges.

5. Study Plans

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

5.1 Studienverlaufsplan

Sem.	Abbr.	Module Name	Mandatory (PF) Elective Catalog (WB)	ECTS	Prüfungslast	Examination Types with Weights
1	HIM	Advanced Mathematics	PF	5	1	▪ final: (digital) written exam or oral examination [100%]
	PLET	Projektleitung	PF	5	1	▪ accompanying: project work [ungraded]
	BTH	Beliebiges Modul aus einem Masterstudiengang der TH Köln	WB	5	≤ 2	▪ selection dependend
	SV	Studienschwerpunktmodule	WB	10	≤ 4	▪ selection dependend
	WM	Allgemeiner Wahlmodulbereich	WB	5	≤ 2	▪ selection dependend
2	FS	Forschungsseminar	PF	10	1	▪ accompanying: term paper or oral contribution [100%]
	SIM	Simulation in der Ingenieurwissenschaft	PF	5	1	▪ accompanying: project work [100%]
	TED	Theoretische Elektrodynamik	PF	5	1	▪ final: (digital) written exam or oral examination [100%]
	SV	Studienschwerpunktmodule	WB	5	≤ 2	▪ selection dependend
	WM	Allgemeiner Wahlmodulbereich	WB	5	≤ 2	▪ selection dependend
3	KOLL	Kolloquium zur Masterarbeit	PF	3	1	▪ final: Colloquium [100%]
	MAA	Masterarbeit	PF	27	1	▪ final: Thesis [100%]

5.2 Alternativer Studienverlaufsplan

Sem.	Abbr.	Module Name	Mandatory (PF) Elective Catalog (WB)	ECTS	Prüfungslast	Examination Types with Weights
1	SV	Studienschwerpunktmodule	WB	5	≤ 2	▪ selection dependend
	WM	Allgemeiner Wahlmodulbereich	WB	5	≤ 2	▪ selection dependend
	TED	Theoretische Elektrodynamik	PF	5	1	▪ final: (digital) written exam or oral examination [100%]
2	SV	Studienschwerpunktmodule	WB	5	≤ 2	▪ selection dependend
	HIM	Advanced Mathematics	PF	5	1	▪ final: (digital) written exam or oral examination [100%]
	WM	Allgemeiner Wahlmodulbereich	WB	5	≤ 2	▪ selection dependend
3	FS	Forschungsseminar	PF	10	1	▪ accompanying: term paper or oral contribution [100%]
	SIM	Simulation in der Ingenieurwissenschaft	PF	5	1	▪ accompanying: project work [100%]
4	PLET	Projektleitung	PF	5	1	▪ accompanying: project work [ungraded]
	BTH	Beliebiges Modul aus einem Masterstudiengang der TH Köln	WB	5	≤ 2	▪ selection dependend
	SV	Studienschwerpunktmodule	WB	5	≤ 2	▪ selection dependend
5	KOLL	Kolloquium zur Masterarbeit	PF	3	1	▪ final: Colloquium [100%]
	MAA	Masterarbeit	PF	27	1	▪ final: Thesis [100%]

6. Modules

The modules of the degree program are described below in alphabetical order.

6.1 CSO - Computersimulation in der Optik

Module ID	CSO_MaET2024
Module Name	Computersimulation in der Optik
Type of Module	Elective Modules
Recognized Course	CSO - Computersimulation in der Optik
ECTS credits	5
Language	deutsch und englisch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Holger Weigand/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Holger Weigand/Professor Fakultät IME
Learning Outcome(s)	
Kompetenz zum Aufbau, zur Analyse, zur Optimierung und Auslegung beleuchtungsoptischer Systeme unter Zuhilfenahme von Software basierend auf nicht-sequenziellem Raytrace. Kompetenz für Software-Entwicklung im Umfeld der Computersimulation (Makro-Programmierung mit Skript-Sprachen, z.B. zum Steuern des In- oder Outputs von Simulationen). Kompetenz zum Erwerb vertiefter Fertigkeiten im Bereich nicht-sequentieller Raytrace-Simulation durch eigenständiges Durcharbeiten von Literatur und Software-Dokumentation, sowie der Einbeziehung des technischen Supports der Software zu einer speziellen Thematik.	
Module Contents	
Lecture / Exercises	
Lab	
Project	
Teaching and Learning Methods	■ Lecture / Exercises ■ Lab ■ Project
Examination Types with Weights	■ accompanying: undefined [ungraded] and ■ final: project work [100%]
Workload	150 Hours
Contact Hours	57 Hours $\triangleq$ 5 SWS
Self-Study	93 Hours
Recommended Prerequisites	
Mandatory Prerequisites	■ Participation in final examination only after successful participation in Lecture / Exercises ■ Participation in final examination only after successful participation in Lab

Recommended Literature

- W. T. Welford, R. Winston: High Collection Nonimaging Optics, Academic Press, 1989; G. Kloos: Entwurf und Auslegung optischer Reflektoren, Expert, 2007; Deutsche und US-Amerikanische Patentschriften; Datenblätter optischer und opto-elektronischer Komponenten; MIT Scheme Reference, Edition 1.62, 1996 (https://groups.csail.mit.edu/mac/ftplib/scheme-7.4/doc-html/scheme_toc.html); H. Ramchandran, A. S. Nair: Scilab (a Free Software to Matlab), S. Chand, 2012; F. Thuselt, F. P. Gennrich: Praktische Mathematik mit MATLAB, Scilab und Octave, Springer 2013; T. Sheth: SCILAB: A Practical Introduction to Programming and Problem Solving, CreateSpace, 2016; C. Gomez: Engineering and Scientific Computing with Scilab, Birkhäuser, 1999;

Use of the Module in Other Study Programs

CSO in Master Elektrotechnik 2020

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6.2 DLO - Deep Learning und Objekterkennung

Module ID	DLO_MaET2024
Module Name	Deep Learning und Objekterkennung
Type of Module	Elective Modules
Recognized Course	DLO - image processing master
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Jan Salmen/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Jan Salmen/Professor Fakultät IME
Learning Outcome(s)	
Die Teilnehmer*innen können selbständig entscheiden, in welchen Situationen sich der Einsatz von Verfahren aus dem Bereich Deep Learning anbietet. Sie können eine entsprechende Lösung entwerfen, iterativ verbessern und praktisch umsetzen. Mögliche Probleme auf dem Weg dahin (z.B. beim Erstellen eines Datensatzes oder beim Training) können sie qualifiziert analysieren und passende Ideen zur Bewältigung entwickeln. Da sie einen guten Überblick über die langjährigen Entwicklungen in Forschung und Technik haben, können sie qualifiziert auf aktuelle Herausforderungen und offene Fragen im Zusammenhang mit Deep Learning schauen. Die Studierenden werden so in die Lage versetzt, sich sowohl im weiteren Studienverlauf als auch im Berufsleben kompetent mit Ansätzen zu beschäftigen, die auf Deep Learning beruhen.	
Module Contents	
Lecture	
Deep learning algorithms and their application for object recognition in images.	
Lab	
training of a neural network evaluation of the performance of a neural network	
Teaching and Learning Methods	▪ Lecture ▪ Lab
Examination Types with Weights	▪ accompanying: exercise lab [ungraded] and ▪ final: (digital) written exam or oral examination or single/multiple choice [100%]
Workload	150 Hours
Contact Hours	34 Hours $\triangleq$ 3 SWS
Self-Study	116 Hours
Recommended Prerequisites	The students should have some basic knowledge about image processing and pattern recognition
Mandatory Prerequisites	Lab requires attendance in the amount of: 4 Termine
Recommended Literature	▪ I. Goodfellow, Y. Bengio und A. Courville. Deep Learning. MIT Press, 2016 ▪ C. C. Aggarwal. Neural Networks and Deep Learning: A Textbook. Springer, 2018 ▪ C. Bishop und H. Bishop. Deep Learning: Foundations and Concepts. Springer, 2024 ▪ D. V. Godoy. Deep Learning with PyTorch Step-by-Step: A Beginner's Guide. Fundamentals. 2022 ▪ D. V. Godoy. Deep Learning with PyTorch Step-by-Step: A Beginner's Guide. Computer Vision. 2022

Use of the Module in Other Study Programs	▪ DLO in Master Elektrotechnik 2020 ▪ DLO in Master Medientechnologie 2020 ▪ DLO in Master Medientechnologie 2024 ▪ DLO in Master Technische Informatik 2020 ▪ DLO in Master Informatik und Systems-Engineering 2024
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6.3 DMC - Digital Motion Control

Module ID	DMC_MaET2024
Module Name	Digital Motion Control
Type of Module	Elective Modules
Recognized Course	DMC - Digital Motion Control
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Jens Onno Krah/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Jens Onno Krah/Professor Fakultät IME
Learning Outcome(s)	
- Servomotoren kennenlernen und betreiben - Servoumrichter kennenlernen und verwenden - Digitale Regelalgorithmen nutzen - Prozessidentifikation und Parameterestimation - Auslegung von Antriebssystemen	
Module Contents	
Lecture / Exercises	
- Structure of servo motors - Structure of servo inverters - Digital control algorithms - Process identification - Design of drive systems	
Lab	
- Direct Digital Control - Quasi-continuous control - Predictor / Observer - Parameterization of a control system - Evaluation of Bode diagrams - Demonstrate action competence - Commissioning of a servocontroller - Minimization of following errors	
Teaching and Learning Methods	- Lecture / Exercises - Lab
Examination Types with Weights	- accompanying: lab report [ungraded] and - final: (digital) written exam or oral examination [100%]
Workload	150 Hours
Contact Hours	45 Hours $\triangleq$ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	RT, DSS

Mandatory Prerequisites	Lab requires attendance in the amount of: 3 Termine
Recommended Literature	▪ Krah, Jens Onno, Vorlesungsskript MC ▪ Krah, Jens Onno: Vorlesungsskript RT (Download) ▪ Handbuch ServoStar 300: www.danahermotion.net ▪ Schultz, G.: Regelungstechnik, Oldenbourg Verlag, München-Wien ▪ Lutz, Wendt: Taschenbuch der Regelungstechnik, Verlag Harri Deutsch
Use of the Module in Other Study Programs	▪ DMC in Master Elektrotechnik 2020 ▪ DMC in Master Technische Informatik 2020 ▪ DMC in Master Informatik und Systems-Engineering 2024
Specifics and Notes	
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6.4 EBA - Elektrische Bahnen

Module ID	EBA_MaET2024
Module Name	Elektrische Bahnen
Type of Module	Elective Modules
Recognized Course	EBA - Electric Railways
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Wolfgang Evers/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Wolfgang Evers/Professor Fakultät IME

Learning Outcome(s)

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

Module Contents

Lecture / Exercises

- Railway vehicles with commutator motors
- * DC railways
- * Alternating current railways
- Railway vehicles with three-phase motors
- * Asynchronous machine
- * Power converter for the asynchronous machine
- * Synchronous machine
- Linear drives
- Magnetic levitation systems
- * Static-catching levitation
- * Dynamic-repulsive hovering
- * Static-repulsive hovering
- Executed and projected magnetic levitation trains
- * Transrapid
- * MagLev system
- Discuss and evaluate the advantages and disadvantages of different systems (power systems, wheel / rail vs. magnetic levitation)
- Classification of electrotechnical solutions in interdisciplinary concepts

Lab

Working out various aspects of railway operation using computer simulations

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Lab
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Examination Types with Weights	▪ accompanying: lab report [ungraded] and ▪ final: oral examination [100%]
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Workload	150 Hours
Contact Hours	45 Hours $\pm$ 4 SWS
Self-Study	105 Hours

Recommended Prerequisites	Fundamentals of electrical engineering, electronics and mechanics Basic understanding of electrical machines
Mandatory Prerequisites	▪ Lab requires attendance in the amount of: 2 Termine ▪ Participation in final examination only after successful participation in Lab
Recommended Literature	▪ Zarko Filipovic, Elektrische Bahnen Springer Verlag, 1989, ISBN 3-540-55093-3
Use of the Module in Other Study Programs	EBA in Master Elektrotechnik 2020
Specifics and Notes	
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6.5 EFA - Elektrische Fahrzeugantriebe

Module ID	EFA_MaET2024
Module Name	Elektrische Fahrzeugantriebe
Type of Module	Elective Modules
Recognized Course	EFA - Electric vehicle drivetrain
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Andreas Lohner/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Andreas Lohner/Professor Fakultät IME

Learning Outcome(s)

Die Studierenden lernen den Aufbau moderner, elektrischer und hybrider Fahrzeugantriebe kennen und sie erstellen die wesentlichen Steuerungs- und Regelungskonzepte der unterschiedlichen Antriebsmaschinen, indem sie Modelle der Maschinen, der Leistungselektronik und der Regelung mit dem Tool Matlab/Simulink modellieren und simulieren, um für verschiedene Anwendungen spezifische Antriebe auswählen, parametrieren und in Betrieb nehmen zu können und um weiterführend auch neue Regelungsverfahren entwickeln zu können.

Module Contents**Lecture / Exercises**

Basic concepts and historical drive development
Mechanical fundamentals, rotating field theory, modeling
Field-oriented control of the induction / synchronous machine
Structure, function and control of the switched reluctance machine
Further vehicle-specific controls
Electric train and bus drives with project examples
Hybrid and electric drive topologies with project examples
Storage technologies for vehicles

Students will be able to capture the functionalities of a modern vehicle propulsion system (hybrid and electric vehicle).
They know and understand the essential control concepts of the different topologies and are able to carry out simple closed-loop control simulations and to use this knowledge to convert the results to the drive.
Students are able to design and dimension drive systems.

Lab

Recognize drive characteristics and properties and record them by measurement (analyze drive system)

Structure the system
Define subsystems
Define subsystem functions
Create drivetrain model
Design drive control
Design energy management algorithms
Understand commercial development tools and use them purposefully
Put control on the target system into operation

Coping with complex tasks in a team
Plan and control simple projects
Comply with agreements and deadlines
Plan and conduct reviews

The students learn methods for the dynamic description and regulation of hybrid and electric vehicle drives and thereby obtain decision-making authority.

The students have experience in dealing with power electronics, drives, classic measuring devices and are able to model drivetrains with a simulation tool.

Students have the ability to understand, dimension and control electric and hybrid drivetrains.

Teaching and Learning	▪ Lecture / Exercises
Methods	▪ Lab

Examination Types with Weights	▪ accompanying: lab report [ungraded] and ▪ final: oral examination [100%]
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Workload	150 Hours
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Contact Hours	45 Hours $\triangleq$ 4 SWS
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Self-Study	105 Hours
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Recommended Prerequisites	Fundamentals of electrical engineering power electronics Basics of electric drives Analogue signals and systems
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Mandatory Prerequisites	Lab requires attendance in the amount of: 1 Termin
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Recommended Literature	▪ Leonhard, W.: Regelung Elektrischer Antriebe, Springer Verlag ▪ Wellenreuter, G.: Automatisieren mit SPS, Vieweg Verlag ▪ Böker, J.: Geregelte Drehstromantriebe, Uni Paderborn ▪ Gerling, D.: Elektrische Maschinen und Antriebe, B.W.-Uni München
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Use of the Module in Other Study Programs	EFA in Master Elektrotechnik 2020
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6.6 EMM - Energiemanagement in Energieverbundsystemen

Module ID	EMM_MaET2024
Module Name	Energiemanagement in Energieverbundsystemen
Type of Module	Elective Modules
Recognized Course	EMM - Energy Management in Interconnected Systems
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Ingo Stadler/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Ingo Stadler/Professor Fakultät IME

Learning Outcome(s)

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

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

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

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

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

Module Contents

Lecture

The students analyse the mechanisms and prerequisites for guaranteeing the stability of interconnected electrical systems by knowing the criteria influencing frequency and voltage stability in order to later be able to develop new measures in a changed energy system based on renewable energies to guarantee stability.

The students analyse the control mechanisms of today's interconnected systems by understanding the terminology, the mode of operation and the organisation of different levels of control power and control energy in order to be able to assess future measures and alternatives for their provision and develop them themselves.

The students know possibilities for sector coupling and can evaluate their use for demand response by creating and solving differential equations for solving balance problems, creating and applying numerical methods for solving non-stationary changes in storage systems in order to evaluate solutions in different time and power ranges of demand response.

Students will know and be able to evaluate energy storage technologies in a wide range of time, energy and power domains by knowing the relevant characteristics and economics to assess their use for different applications.

The students are able to name and analyse the various possibilities for establishing the reactive power balance in interconnected systems by applying the line equations for network analysis in order to be able to guarantee the voltage quality with various measures.

Project

Changing current projects are worked on.

Teaching and Learning Methods	▪ Lecture ▪ Project
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Examination Types with Weights	▪ accompanying: project work [50%] and ▪ final: (digital) written exam [50%]
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Workload	150 Hours
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Contact Hours	34 Hours $\pm$ 3 SWS
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Self-Study	116 Hours
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Recommended Prerequisites	None
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Mandatory Prerequisites	Project requires attendance in the amount of: 3 Termine
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Recommended Literature	
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Use of the Module in Other Study Programs	EMM in Master Elektrotechnik 2020
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6.7 ERMK - Entrepreneurship, Gewerblicher Rechtsschutz, Market Knowledge

Module ID	ERMK_MaET2024
Module Name	Entrepreneurship, Gewerblicher Rechtsschutz, Market Knowledge
Type of Module	Elective Modules
Recognized Course	GER - Industrial property protection
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every term
Module Coordinator	Prof. Dr. Holger Weigand/Professor Fakultät IME
Lecturer(s)	Ladrière
Learning Outcome(s)	
Befähigung zum unternehmerischen Denken Einschätzung des Innovationspotentials neuer technischer Entwicklungen Verständnis der Mechanismen des Marktes im Hinblick auf neue technische Innovationen	
Module Contents	
Lecture	
Types of industrial property rights, significance for companies and inventors, significance of employee invention law and inventor personality law, prerequisites for protection, term of industrial property rights, structure of an application, life cycle from application to patent, subsequent applications, examination and opposition procedures, national, European and international applications, utility models, trademarks, design, law on the protection of secrets, professional field of patent engineer. Carry out a patent search; determine the relevant type of protective right for a given case; be able to correctly file an application with regard to its formal structure; weigh up the advantages and disadvantages of national, European and international applications in a specific application; check the validity of a patent; develop a basic IP strategy.	
Seminar	
Types of industrial property rights, significance for companies and inventors, significance of employee invention law and inventor personality law, prerequisites for protection, term of industrial property rights, structure of an application, life cycle from application to patent, subsequent applications, examination and opposition procedures, national, European and international applications, utility models, trademarks, design, law on the protection of secrets, professional field of patent engineer. Carry out a patent search; determine the relevant type of protective right for a given case; be able to correctly file an application with regard to its formal structure; weigh up the advantages and disadvantages of national, European and international applications in a specific application; check the validity of a patent; develop a basic IP strategy.	
Teaching and Learning Methods	▪ Lecture ▪ Seminar
Examination Types with Weights	▪ accompanying: oral contribution [100%]
Workload	150 Hours
Contact Hours	34 Hours $\pm$ 3 SWS
Self-Study	116 Hours
Recommended Prerequisites	

**Mandatory
Prerequisites**

**Recommended
Literature**

Use of the Module in	▪ ERMK in Master Medientechnologie 2024
Other Study Programs	▪ XIM in Master Technische Informatik 2020

Specifics and Notes

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6.8 ESD - Embedded Systems Design

Module ID	ESD_MaET2024
Module Name	Embedded Systems Design
Type of Module	Elective Modules
Recognized Course	ESD - Embedded Systems Design
ECTS credits	5
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Markus Cremer/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Markus Cremer/Professor Fakultät IME

Learning Outcome(s)

Die Studierenden können die Machbarkeit der Entwicklung einer Produktidee im Bereich der Embedded Systems in Bezug auf praktische Realisierbarkeit, Aufwand, Zeit und Kosten und mit vorausschauendem Blick auf den gesamten Entwicklungsprozess sicher beurteilen. Hierzu setzen sie, ausgehend von einer eigenen Produktidee, Methoden und Hilfsmittel (z.B. Software-Tools, Konzepte, Best-Practices, v.a. auch Hardwareentwicklung) eines typischen industriellen Entwicklungsprozesses für Embedded Systems eigenständig praktisch um. Später sind die Studierenden in der Lage, diesen gesamten Entwicklungsprozess in der Industrie oder in Forschungsprojekten autonom zu bewerten und umzusetzen.

Module Contents

Lecture / Exercises

The exact content will not be determined until the summer semester 2025.

Project

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Project
Examination Types with Weights	▪ accompanying: project work [100%]
Workload	150 Hours
Contact Hours	45 Hours $\triangleq$ 4 SWS
Self-Study	105 Hours
Recommended Prerequisites	Basic knowledge of electrical engineering (simple analog and digital circuits) Basic knowledge of embedded systems (basics of microcontrollers incl. implementation of firmware)
Mandatory Prerequisites	

Recommended Literature

- Murti, K. (2022). Design Principles for Embedded Systems. Springer Singapore. <https://doi.org/10.1007/978-981-16-3293-8>
- Schmidt, R., Hauschild, D., & Kluge, I. (2024). Elektronik Design: Theorie und Praxis. Elektronik Design: Theorie Und Praxis. <https://doi.org/10.1007/978-3-662-68676-8>
- Ünsalan, C., Gürhan, H. D., & Yücel, M. E. (2022). Embedded system design with ARM Cortex-M microcontrollers: Applications with C, C++ and MicroPython. Embedded System Design with ARM Cortex-M Microcontrollers: Applications with C, C++ and MicroPython, 1–569. <https://doi.org/10.1007/978-3-030-88439-0>
- Morshed, B. I. (2021). Embedded systems - A hardware-software co-design approach: Unleash the power of arduino! In Embedded Systems - A Hardware-Software Co-Design Approach: Unleash the Power of Arduino! Springer International Publishing. <https://doi.org/10.1007/978-3-030-66808-2>
- Marwedel, P. (2021). Embedded System Design. <https://doi.org/10.1007/978-3-030-60910-8>
- Lienig, J., & Scheible, J. (2020). Fundamentals of Layout Design for Electronic Circuits. Fundamentals of Layout Design for Electronic Circuits. <https://doi.org/10.1007/978-3-030-39284-0>

Use of the Module in Other Study Programs

- ESD in Master Communication Systems and Networks 2024
- ESD in Master Medientechnologie 2024
- ESD in Master Informatik und Systems-Engineering 2024

Permanent Links to Organization

[ILU course](#)

Specifics and Notes**Last Update**

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6.9 FS - Forschungsseminar

Module ID	FS_MaET2024
Module Name	Forschungsseminar
Type of Module	Mandatory Module
Recognized Course	FS - Research Seminar
ECTS credits	10
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	2
Frequency of Course	every term
Module Coordinator	Prof. Dr. Jens Onno Krah/Professor Fakultät IME
Lecturer(s)	verschiedene Dozenten*innen / diverse lecturers
Learning Outcome(s)	
Module Contents	
Seminar	
In the seminar and at the poster presentation the student presents and defends his work. The discussion and discourse in the subject as a skill of the candidate is thus achieved. Independent research on the scientific question leads to a high increase in knowledge, also to the right and left of the actual core question. In the seminar and on the poster presentation the student learns about other scientific questions.	
Teaching and Learning Methods	Seminar
Examination Types with Weights	■ accompanying: term paper or oral contribution [100%]
Workload	300 Hours
Contact Hours	12 Hours $\triangleq$ 1 SWS
Self-Study	288 Hours
Recommended Prerequisites	Since the professional orientation of the seminar takes place in coordination with the supervising lecturer, the competence "scientific working" is rather to be brought along as a prerequisite, which is already trained in Bachelor's thesis. A further prerequisite is that the student is able to become familiar with the topics independently.
Mandatory Prerequisites	Seminar requires attendance in the amount of: 4 Präsentationen und 1 Posterausstellung
Recommended Literature	■ die empfohlene Literatur hängt vom bearbeiteten Forschungsthema ab
Use of the Module in Other Study Programs	FS in Master Elektrotechnik 2020
Specifics and Notes	
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6.10 HIM - Advanced Mathematics

Module ID	HIM_MaET2024
Module Name	Advanced Mathematics
Type of Module	Mandatory Module
Recognized Course	HIM - Advanced Mathematics
ECTS credits	5
Language	deutsch und englisch
Duration of Module	1 Semester
Recommended Semester	1
Frequency of Course	every term
Module Coordinator	Prof. Dr. Heiko Knospe/Professor Fakultät IME
Lecturer(s)	▪ Prof. Dr. Heiko Knospe/Professor Fakultät IME ▪ Prof. Dr. Hubert Randerath/Professor Fakultät IME ▪ Prof. Dr. Beate Rhein/Professor Fakultät IME

Learning Outcome(s)

Was: Das Modul vermittelt grundlegende Konzepte und Methoden der Mathematik, die in den Ingenieurwissenschaften benötigt werden (K. 8). Die Abstraktion und mathematischen Formalisierung von Problemen soll erlernt und angewendet werden (K. 2). Die Studierenden lernen die Anwendung mathematischer Methoden (K. 16). Es soll die Anwendung statistischer Verfahren und die Begründung wissenschaftlicher Aussagen erlernt werden (K. 17).

Womit: Der Dozent/die Dozentin vermittelt Wissen und Basisfertigkeiten in der Vorlesung. In der Übung bearbeiten die Studierenden unter Anleitung Aufgaben. Die Übung wird durch Hausaufgaben und Online-Aufgaben (E-Learning) ergänzt.

Wozu: Fortgeschrittene Mathematik-Kenntnisse (beispielweise in Vektoranalysis, Statistik und Optimierung) werden in mehreren Modulen des Studiengangs benötigt. Mathematische Methoden sind essentiell für Ingenieure, die wissenschaftlich arbeiten und wissenschaftliche Erkenntnisse anwenden und erweitern (HF2).

Module Contents**Lecture / Exercises**

A combination of:

- Vector Analysis
- Probability Theory, Statistics and Multivariate Statistics
- Stochastic processes
- Optimization

Vector Analysis

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

Probability and Statistics

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

Multivariate Statistics

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

Stochastic Processes

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

Optimization

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

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Teaching and Learning Lecture / Exercises**Methods**

Examination Types with Weights ■ final: (digital) written exam or oral examination [100%]

Workload 150 Hours

Contact Hours 34 Hours $\pm$ 3 SWS

Self-Study 116 Hours

Recommended Prerequisites Differential and integral calculus and linear algebra (Bachelor-level mathematics)

Mandatory Prerequisites

Recommended Literature

- K. Burg, H. Haf, F. Wille, A. Meister, Vektoranalysis - Höhere Mathematik für Ingenieure, Naturwissenschaftler und Mathematiker, Springer Vieweg
- E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons
- L. Papula, Mathematik für Ingenieure und Naturwissenschaftler Band 3, Springer Vieweg
- R. E. Walpole, R. H. Myers, S. L. Myers, K. Ye, Probability & Statistics for Engineers & Scientists, Prentice Hall
- S. M. Ross, Probability and Statistics for Engineers and Scientists, Elsevier
- S. M. Ross, Stochastic Processes, John Wiley & Sons
- U. Krengel, Einführung in die Wahrscheinlichkeitstheorie und Statistik
- A. Koop, H. Moock, Lineare Optimierung, Springer
- R. Reinhardt, A. Hoffmann, T. Gerlach, Nichtlineare Optimierung, Springer
- M. Ulbrich, S. Ulbrich, Nichtlineare Optimierung, Birkhäuser

Use of the Module in Other Study Programs

- HIM in Master Communication Systems and Networks 2020
- HIM in Master Communication Systems and Networks 2024
- HIM in Master Elektrotechnik 2020
- HIM in Master Technische Informatik 2020
- HIM in Master Informatik und Systems-Engineering 2024

Specifics and Notes

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6.11 HSUT - Hochspannungsübertragungstechnik

Module ID	HSUT_MaET2024
Module Name	Hochspannungsübertragungstechnik
Type of Module	Elective Modules
Recognized Course	HSUT - High Voltage Transmission Technology
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Christof Humpert/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Christof Humpert/Professor Fakultät IME

Learning Outcome(s)

Die Studierenden können Systeme und Betriebsmittel der Hochspannungsübertragungstechnik hinsichtlich technischer und betriebswirtschaftlicher Kriterien analysieren und auswählen, indem sie

- Anforderungen an Übertragungssysteme erkennen,
- Spannungsbelastungen im Nenn- und Fehlerfall bestimmen und Maßnahmen zur Reduktion der Belastungen auslegen,
- Vor- und Nachteile aktueller und zukünftiger Technologien analysieren und
- vereinfachte Wirtschaftlichkeitsberechnungen durchführen,

um später fundierte Entscheidungen hinsichtlich des optimalen Aus- und Umbaus der elektrischen Netze unter gesellschaftlichen und politischen Randbedingungen treffen zu können.

Module Contents

Lecture / Exercises

Overvoltages and insulation coordination

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

Systems of high voltage transmission

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

Equipment of high voltage transmission

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

Determine the stresses of transmission systems

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

Determine business aspects

- Carry out investment cost comparison
- Perform operating cost comparison

Project

Deepening a specific problem in electrical engineering using a calculation example

Solve project task in the team

Compile the basics of a calculation software

Perform numerical calculations

Compare numerical results with analytical

Discuss results related to practical application

Summarize results in a report

Lab

Generation and measurement of AC, DC and impulse voltages

Propagation and limitation of overvoltages

Plan high voltage tests

Dimension high voltage test circuits

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

Teaching and Learning Methods

- Lecture / Exercises
- Project
- Lab

Examination Types with Weights

- accompanying: lab report [20%] and
- accompanying: lab report [20%] and
- final: oral examination [60%]

Workload 150 Hours

Contact Hours 57 Hours $\pm$ 5 SWS

Self-Study 93 Hours

Recommended Prerequisites

Basics of electrical engineering and electronics
Basic understanding of electric fields in dielectrics

Mandatory Prerequisites

- Lab requires attendance in the amount of: 3 Termine
- Participation in final examination only after successful participation in Lab

Recommended Literature

- Küchler, Andreas: Hochspannungstechnik: Grundlagen – Technologie – Anwendung (Springer)
- Heuck, Klaus; Dettmann, Klaus-Dieter; Schulz, Detlef: Elektrische Energieversorgung (Springer)

Use of the Module in Other Study Programs

HSUT in Master Elektrotechnik 2020

Permanent Links to Organization

[ILU course for High Voltage Transmission Technology.](#)

Specifics and Notes

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6.12 IBD - InnoBioDiv

Module ID	IBD_MaET2024
Module Name	InnoBioDiv
Type of Module	Elective Modules
Recognized Course	IBD - InnoBioDiv student projects
ECTS credits	5
Language	englisch
Duration of Module	0.5 Semester
Recommended Semester	1-2
Frequency of Course	every term
Module Coordinator	Prof. Dr. Uwe Dettmar/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Uwe Dettmar/Professor Fakultät IME

Learning Outcome(s)

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

Module Contents

Seminar

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

Project

The students acquire...

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

At the end, students will have

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

Teaching and Learning Methods	▪ Seminar ▪ Project
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Examination Types with Weights	▪ accompanying: project work [100%]
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Workload	150 Hours
Contact Hours	23 Hours $\pm$ 2 SWS
Self-Study	127 Hours

Recommended Prerequisites	- fluent English since working intercultural and interdisciplinary teams. - basic knowledge in IoT and robotics desirable - ability to work in a team - basic knowledge in plant biology are not mandatory
Mandatory Prerequisites	▪ Seminar requires attendance in the amount of: 8 Stunden ▪ Project requires attendance in the amount of: 5 meetings for project discussions
Recommended Literature	▪ https://farm.bot/ ▪ Arif, Tarik M.: Deep Learning on Embedded Systems: A Hands-On Approach Using Jetson Nano and Raspberry Pi, Wiley, 2025, ISBN:978-1-394-26927-3 ▪ Agrawal, D. P. (2017). Embedded Sensor Systems. Springer. ▪ Marwedel, Peter: Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems, and the Internet of Things, Springer, 2021, ISBN 978-3-030-60910-8 ▪ L. Urry, S. Wassermann: Campbell Biology AP Edition (12th Edition), Pearson, ISBN-13: 978-0-13-648687-9 ▪ Taiz, L., Møller, I. M., Murphy, A., & Zeiger, E. (2022). Plant Physiology and Development. Oxford University Press.
Use of the Module in Other Study Programs	▪ IBD in Master Communication Systems and Networks 2020 ▪ IBD in Master Communication Systems and Networks 2024 ▪ IBD in Master Medientechnologie 2024 ▪ IBD in Master Technische Informatik 2020 ▪ IBD in Master Informatik und Systems-Engineering 2024
Permanent Links to Organization	<u>Course description in the learning platform</u>
Specifics and Notes	Block course from the beginning of October to mid-November (7 weeks), optional preparation time to build up basic knowledge in the last week of September
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6.13 ITF - IT-Forensik

Module ID	ITF_MaET2024
Module Name	IT-Forensik
Type of Module	Elective Modules
Recognized Course	ITF - IT forensics
ECTS credits	5
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Studiengangsleiter(in) Master Technische Informatik / Informatik und Systems-Engineering
Lecturer(s)	Jürgen Bornemann/Lehrbeauftragter

Learning Outcome(s)

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

Module Contents

Lecture / Exercises

Basic concepts of cyber security and digital forensics

Typical vulnerabilities, threats and risks

Dangers with mobile systems, home office, WLANs

Basics and working methods of IT forensics

Forensic documentation creation

Common tools for forensic investigations

Recognize and secure digital evidence

Open source forensics

File system forensics

Forensic analysis of mobile systems

Vulnerabilities, threats, attacks on network structures

KALI Linux - Operating System for Vulnerability and Pentesting

Project

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

Teaching and Learning Methods

- Lecture / Exercises
- Project

Examination Types with Weights

- accompanying: project work [100%]

Workload 150 Hours

Contact Hours 45 Hours $\pm$ 4 SWS

Self-Study 105 Hours

**Recommended
Prerequisites**

**Mandatory
Prerequisites**

**Recommended
Literature**

Use of the Module in Other Study Programs	▪ ITF in Master Communication Systems and Networks 2020
	▪ ITF in Master Communication Systems and Networks 2024
	▪ ITF in Master Elektrotechnik 2020
	▪ ITF in Master Medientechnologie 2020
	▪ ITF in Master Medientechnologie 2024
	▪ ITF in Master Technische Informatik 2020
	▪ ITF in Master Informatik und Systems-Engineering 2024

Specifics and Notes

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6.14 KOLL - Kolloquium zur Masterarbeit

Module ID	KOLL_MaET2024
Module Name	Kolloquium zur Masterarbeit
Type of Module	Mandatory Module
Recognized Course	MAKOLL - Colloquium
ECTS credits	3
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	3
Frequency of Course	every term
Module Coordinator	Studiengangsleiter(in) Master Technische Informatik / Informatik und Systems-Engineering
Lecturer(s)	verschiedene Dozenten*innen / diverse lecturers
Learning Outcome(s)	- Darstellung von Forschungsergebnissen in einer Präsentation in vorgegebenem engen zeitlichen Rahmen - Fachliche und außerfachliche Bezüge der eigenen Arbeit darstellen und begründen - Eigene Lösungswege und gewonnene Erkenntnisse darstellen und diskutieren
Module Contents	
Colloquium	The colloquium serves to determine whether the student is able to present the results of the Master's thesis, its technical and methodological foundations, interdisciplinary contexts and extracurricular references orally, to justify them independently and to assess their significance for practice
Teaching and Learning Methods	Colloquium
Examination Types with Weights	▪ final: Colloquium [100%]
Workload	90 Hours
Contact Hours	0 Hours $\triangleq$ 0 SWS
Self-Study	90 Hours
Recommended Prerequisites	
Mandatory Prerequisites	▪ Module MAA: Die Masterarbeit muss abgeschlossen sein, damit sie im Kolloquium ganzheitlich und abschließend präsentiert werden kann. ▪ See exam regulations §29, paragraph 2
Recommended Literature	
Use of the Module in Other Study Programs	▪ KOLL in Master Communication Systems and Networks 2020 ▪ KOLL in Master Communication Systems and Networks 2024 ▪ KOLL in Master Elektrotechnik 2020 ▪ KOLL in Master Medientechnologie 2020 ▪ KOLL in Master Medientechnologie 2024 ▪ KOLL in Master Technische Informatik 2020 ▪ KOLL in Master Informatik und Systems-Engineering 2024
Specifics and Notes	See also examination regulations §29.
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6.15 LSPW - Leistungselektronische Stellglieder für PV- und Windkraftanlagen

Module ID	LSPW_MaET2024
Module Name	Leistungselektronische Stellglieder für PV- und Windkraftanlagen
Type of Module	Elective Modules
Recognized Course	LSPW - Power Electronics for PV and Wind
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Andreas Lohner/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Christian Dick/Professor Fakultät IME

Learning Outcome(s)

Die Studierenden lernen elektronische und elektromagnetische Strukturen, Topologien und Regelungsverfahren verschiedener erneuerbarer Energieerzeugungsanlagen (Photovoltaik & Wind) erläutern, erklären und z. T. auch entwickeln, indem sie

- die gesamte anlagenspezifische Systemtechnik in wesentliche Teile (Elektromechanik, Leistungselektronik, Steuerung/Regelung) gliedern,
- Rechnermodelle von allen Teilen und auch der Gesamtanlage entwerfen und mit einem Simulationstool simulieren,
- mit Leistungselektronik, Antrieben, klassischen Messgeräten umgehen,
- sowie spezifische Regelungsalgorithmen erkennen und verstehen,

um als Ingenieure

- Erneuerbare Energieerzeugungsanlagen zu konzeptionieren und zu dimensionieren,
- Leistungselektronische Komponenten für EE zu entwickeln und
- für EE spezifische Regelungen zu entwerfen.

Module Contents**Lecture / Exercises**

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

Principles of grid-connected as well as of idle solar inverters for photovoltaic systems

Physics of the solar cell

Inverter topologies

System architectures: central, string and module inverters

Control methods: PWM, MPP tracking etc.

Principles of wind turbines

double-fed induction machine

Plant with synchronous machine

Wind power-specific control algorithms

The students will be able to explain electronic and electromagnetic structures, topologies and control methods of various renewable energy generation systems (photovoltaic, wind, etc.).

The students possess the ability to dissect the entire plant-specific system technology into essential subsections, to develop or to project individual aspects and thus to carry out individual steps of a synthesis.

The relationship to reality, in particular with regard to new regulatory, normative framework conditions that accompany the energy transition, is being established. This enables the student to describe the actuators as part of an intelligent network in the superordinate context in order to later select or develop the correct actuators.

The students become acquainted with methods for the dynamic description and regulation of renewable energy generation plants and thereby obtain decision-making authority.

The students have experience in handling power electronics, drives, classical measuring devices and are able to model actuators with a simulation tool.

Students have the ability to understand, dimension and regulate electrical actuators for renewable energy generation.

Lab

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

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

Students can handle a standard commercial modeling and simulation tool.

The students understand the working behavior of power electronic actuators.

The students can solve tasks in a small team.

They can analyze measurement results and gain insights into the measurement object.

They can model and simulate a real system.

Teaching and Learning ■ Lecture / Exercises

Methods ■ Lab

Examination Types with ■ accompanying: lab report or oral contribution [ungraded] and

Weights ■ final: oral examination [100%]

Workload 150 Hours

Contact Hours 45 Hours $\pm$ 4 SWS

Self-Study 105 Hours

Recommended Fundamentals of electrical engineering
Prerequisites power electronics
 Basics of electric drives
 Analogue signals and systems

Mandatory Lab requires attendance in the amount of: Labortermine (8 Std.)
Prerequisites

Recommended Literature	■ Hau E.: Windkraftanlagen - Grundlagen, Technik, Einsatz, Wirtschaftlichkeit, Springer Verlag ■ Mertens, K.: Photovoltaik - Lehrbuch zu Grundlagen, Technologie und Praxis, Hanser Verlag ■ Sahan, B.: Wechselrichtersysteme mit Stromzwischenkreis zur Netzanbindung von Photovoltaik-Generatoren, KDEE Kassel
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Use of the Module in Other Study Programs	LSPW in Master Elektrotechnik 2020
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Specifics and Notes

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Additional module variant with same learning outcomes

Module ID	LSPW_MaET2024
Module Name	Leistungselektronische Stellglieder für PV- und Windkraftanlagen
Type of Module	Elective Modules
Recognized Course	LSPW - Power Electronics for PV and Wind
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Andreas Lohner/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Christian Dick/Professor Fakultät IME

Learning Outcome(s)

Die Studierenden lernen elektronische und elektromagnetische Strukturen, Topologien und Regelungsverfahren verschiedener erneuerbarer Energieerzeugungsanlagen (Photovoltaik & Wind) erläutern, erklären und z. T. auch entwickeln, indem sie

- die gesamte anlagenspezifische Systemtechnik in wesentliche Teile (Elektromechanik, Leistungselektronik, Steuerung/Regelung) gliedern,
- Rechnermodelle von allen Teilen und auch der Gesamtanlage entwerfen und mit einem Simulationstool simulieren,
- mit Leistungselektronik, Antrieben, klassischen Messgeräten umgehen,
- sowie spezifische Regelungsalgorithmen erkennen und verstehen,

um als Ingenieure

- Erneuerbare Energieerzeugungsanlagen zu konzeptionieren und zu dimensionieren,
- Leistungselektronische Komponenten für EE zu entwickeln und
- für EE spezifische Regelungen zu entwerfen.

Module Contents**Lecture / Exercises**

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

Principles of grid-connected as well as of idle solar inverters for photovoltaic systems

Physics of the solar cell

Inverter topologies

System architectures: central, string and module inverters

Control methods: PWM, MPP tracking etc.

Principles of wind turbines

double-fed induction machine

Plant with synchronous machine

Wind power-specific control algorithms

The students will be able to explain electronic and electromagnetic structures, topologies and control methods of various renewable energy generation systems (photovoltaic, wind, etc.).

The students possess the ability to dissect the entire plant-specific system technology into essential subsections, to develop or to project individual aspects and thus to carry out individual steps of a synthesis.

The relationship to reality, in particular with regard to new regulatory, normative framework conditions that accompany the energy transition, is being established. This enables the student to describe the actuators as part of an intelligent network in the superordinate context in order to later select or develop the correct actuators.

The students become acquainted with methods for the dynamic description and regulation of renewable energy generation plants and thereby obtain decision-making authority.

The students have experience in handling power electronics, drives, classical measuring devices and are able to model actuators with a simulation tool.

Students have the ability to understand, dimension and regulate electrical actuators for renewable energy generation.

Lab

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

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

Students can handle a standard commercial modeling and simulation tool.

The students understand the working behavior of power electronic actuators.

The students can solve tasks in a small team.

They can analyze measurement results and gain insights into the measurement object.

They can model and simulate a real system.

Teaching and Learning ■ Lecture / Exercises

Methods ■ Lab

Examination Types with ■ accompanying: oral contribution [ungraded] and

Weights ■ final: oral examination [100%]

Workload 150 Hours

Contact Hours 45 Hours $\pm$ 4 SWS

Self-Study 105 Hours

Recommended Fundamentals of electrical engineering
Prerequisites power electronics
 Basics of electric drives
 Analogue signals and systems

Mandatory Lab requires attendance in the amount of: 8 Unterrichtsstunden
Prerequisites

**Recommended
Literature**

- Hau E.: Windkraftanlagen - Grundlagen, Technik, Einsatz, Wirtschaftlichkeit, Springer Verlag
- Mertens, K.: Photovoltaik - Lehrbuch zu Grundlagen, Technologie und Praxis, Hanser Verlag
- Sahan, B.: Wechselrichtersysteme mit Stromzwischenkreis zur Netzanbindung von Photovoltaik-Generatoren, KDEE Kassel

**Use of the Module in
Other Study Programs**

LSPW in Master Elektrotechnik 2020

Specifics and Notes

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6.16 MAA - Masterarbeit

Module ID	MAA_MaET2024
Module Name	Masterarbeit
Type of Module	Mandatory Module
Recognized Course	MAA - Master thesis
ECTS credits	27
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	3
Frequency of Course	every term
Module Coordinator	Studiengangsleiter(in) Master Technische Informatik / Informatik und Systems-Engineering
Lecturer(s)	verschiedene Dozenten*innen / diverse lecturers

Learning Outcome(s)

Das Modul vermittelt folgende Kenntnisse und Fertigkeiten:

- Komplexe Aufgabenstellungen beurteilen
- Selbstständiges Verfassen eines längeren wissenschaftlichen Textes
- Gute Praxis des wissenschaftlichen Arbeitens anwenden
- Darstellung von Forschungsergebnissen in Form eines wissenschaftlichen Artikels nach den Vorgaben gängiger Fachzeitschriften bzw. Konferenzen
- Selbstständiges und systematisches Bearbeiten einer komplexen ingenieurwissenschaftlichen Aufgabenstellung unter Verwendung wissenschaftlicher Methoden
- Lösungsstrategien entwickeln und umsetzen
- Wissenschaftliche Literatur recherchieren und auswerten
- Eigene Arbeit bewerten und einordnen

Individuelle Vereinbarung des Studierenden mit einem Dozenten der MT bzw. F07 über eine qualifizierte Ingenieur Tätigkeit mit einer studiengangsbezogenen Aufgabenstellung mit wissenschaftlichem Anspruch. Die Masterarbeit kann auch extern in einer Forschungsorganisation, einem Wirtschaftsunternehmen o.ä. durchgeführt werden. Die Betreuung erfolgt durch den Dozenten. Die Masterarbeit adressiert die Entwicklung komplexer Medientechnologien unter interdisziplinären Bedingungen (HF1) und das wissenschaftliche Arbeiten um wissenschaftliche Erkenntnisse zu erweitern (HF2)."

Module Contents

Thesis

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

Teaching and Learning Methods	Thesis
Examination Types with Weights	▪ final: Thesis [100%]
Workload	810 Hours
Contact Hours	0 Hours $\pm$ 0 SWS
Self-Study	810 Hours
Recommended Prerequisites	See examination regulations §26
Mandatory Prerequisites	see exam regulations §26 paragraph 1

**Recommended
Literature**

Use of the Module in Other Study Programs	▪ MAA in Master Communication Systems and Networks 2020 ▪ MAA in Master Communication Systems and Networks 2024 ▪ MAA in Master Elektrotechnik 2020 ▪ MAA in Master Medientechnologie 2020 ▪ MAA in Master Medientechnologie 2024 ▪ MAA in Master Technische Informatik 2020 ▪ MAA in Master Informatik und Systems-Engineering 2024
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Specifics and Notes	See also examination regulations §24ff. Contact a professor of the faculty early on for the initial supervision of the thesis.
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6.17 MLWR - Maschinelles Lernen und wissenschaftliches Rechnen

Module ID	MLWR_MaET2024
Module Name	Maschinelles Lernen und wissenschaftliches Rechnen
Type of Module	Elective Modules
Recognized Course	MLWR - Machine Learning and Scientific Computing
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Beate Rhein/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Beate Rhein/Professor Fakultät IME

Learning Outcome(s)

Was:

fortgeschrittene Methoden des maschinellen Lernens auf typische Datensätze der technischen Informatik anwenden
Fallstricke des Maschinellen Lernens in der Vorgehensweise erkennen
für eine Aufgabenstellung das geeignete Verfahren bestimmen und anwenden können
Qualität von Datensätzen beurteilen und verbessern
Datenschutzgesetze kennen
weit verbreitete Software des maschinellen Lernens anwenden

Womit:

Die Methoden werden anhand eines Vortrags oder per Lernvideos vermittelt und in Vorlesung und Übung direkt angewendet. Jeder Student wird ein Projekt durchführen (je nach Anzahl der Studierenden in Gruppenarbeit), bei der er sich Teile des Stoffes selber erarbeitet.

Wozu:

Maschinelles Lernen wird bei den späteren Arbeitgebern immer mehr eingeführt, etwa in der Robotik, aber auch zur Überwachung und Steuerung von Produktionsprozessen oder Energiesystemen und zur Auswertung von Kundendaten, hier ist ein verantwortlicher Einsatz von Daten wichtig.

Module Contents**Lecture / Exercises**

Approximation methods
metamodeling
regression

Multi-criteria optimization
formulation
Pareto front
algorithms
visualization

Advanced Cluster Analysis

Association Pattern Mining

Outlier Detection

Advanced classification procedures

possibly text recognition, web mining, time series analysis

Lab

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

Teaching and Learning Methods

- Lecture / Exercises
- Lab

Examination Types with Weights

- accompanying: project work [20%] and
- final: oral examination [80%]

Workload 150 Hours

Contact Hours 45 Hours $\pm$ 4 SWS

Self-Study 105 Hours

Recommended Prerequisites Basic knowledge of probability theory and machine learning

Mandatory Prerequisites

- Lecture / Exercises requires attendance in the amount of: 6 Stunden
- Lab requires attendance in the amount of: 2 Termine
- Participation in final examination only after successful participation in Lab

Recommended Literature

- A. Geron: Hand-on Machine Learning, O'Reilly Verlag
- J. Alamar: Hands-on Large Language Models, O'Reilly Verlag

Use of the Module in Other Study Programs

- MLWR in Master Communication Systems and Networks 2020
- MLWR in Master Communication Systems and Networks 2024
- MLWR in Master Elektrotechnik 2020
- MLWR in Master Medientechnologie 2024
- MLWR in Master Technische Informatik 2020
- MLWR in Master Informatik und Systems-Engineering 2024

Specifics and Notes

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6.18 NLO - Nichtlineare Optik

Module ID	NLO_MaET2024
Module Name	Nichtlineare Optik
Type of Module	Elective Modules
Recognized Course	NLO - Nonlinear optics
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Uwe Oberheide/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Uwe Oberheide/Professor Fakultät IME

Learning Outcome(s)

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

Module Contents**Lecture / Exercises**

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

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

Seminar

Presentations on applications/processes based on the content of the course (transfer of course content to other applications).

Examples:

- spectral broadening in a femtosecond laser by self-phase modulation
- temporal measurement of ultrashort laser pulses
- compensation of imaging errors by the use of phase conjugating mirrors
- laser induced nuclear fusion
- multiphoton processes
- generation and application of higher harmonics
- optical parametric oscillators
- free-electron laser

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

Teaching and Learning ■ Lecture / Exercises

Methods ■ Seminar

Examination Types with Weights ■ accompanying: oral contribution [ungraded] and
 ■ final: oral examination or (digital) written exam [100%]

Workload 150 Hours

Contact Hours 45 Hours $\pm$ 4 SWS

Self-Study 105 Hours

Recommended Prerequisites Physics: wave propagation, phase velocity
 Laser technology: laser types, basic principle of stimulated emission
 Light-matter interaction: absorption, scattering, refractive index, birefringence

Mandatory Prerequisites Seminar requires attendance in the amount of: Vortragstermine

Recommended Literature	▪ Boyd – Nonlinear Optics, Elsevier ▪ Pedrotti – Optik für Ingenieure, Springer ▪ Saleh, Teich – Grundlagen der Photonik, Wiley VCH
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Use of the Module in Other Study Programs	NLO in Master Elektrotechnik 2020
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Specifics and Notes

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6.19 OSA - Optische Spektroskopie und Anwendungen

Module ID	OSA_MaET2024
Module Name	Optische Spektroskopie und Anwendungen
Type of Module	Elective Modules
Recognized Course	OSA - Optical Spectroscopy and Applications
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Michael Gartz/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Michael Gartz/Professor Fakultät IME

Learning Outcome(s)

Was: Die Studierenden können optische Messprobleme analysieren und eigene Spektrometer-Systeme synthetisieren und hinsichtlich der optischen und wirtschaftlichen Eigenschaften bewerten. Sie können Spektrometer designen, konstruieren, realisieren und damit die aus den Kundenanforderungen extrahierten Messgrößen optimal bestimmen und die Ergebnisse interpretieren.

Womit: indem die Studierenden mittels der Projektarbeit die in den Vorlesungen vermittelten Theorien anwenden, beurteilen und bewerten, mittels eigener Recherchen und Projektbesprechungen ihren Lösungsansatz entwickeln, realisieren und in eigenen Vorträgen darstellen, präsentieren und bewerten,

Wozu: um später in Entwicklungsabteilungen von optischen Messtechnikunternehmen Messprobleme zu verstehen, zu analysieren, konstruktive Lösungen zu erarbeiten und zu realisieren bis zum serienreifen Endprodukt. Um als beratende Ingenieure Kundenprobleme zu analysieren und mit am Markt befindlichen Systemen Applikationen zu erstellen, die die optischen Messprobleme lösen oder am Markt befindliche Messsysteme beurteilen und bewerten können, ob sie zur Lösung geeignet sind. Um erarbeitete oder bewertete optische Lösungen wissenschaftlich einwandfrei zu präsentieren.

Module Contents

Lecture

- First application
- Layer thickness measurement by optical spectroscopy
- measuring principle
- superstructure
- sensitivity
- Basics of spectroscopy
- dispersion
- angular dispersion
- linear dispersion
- prism
- Beam path in prism
- Dispersion of the prism
- diffraction grating
- Diffraction at the grating
- Dispersion at the grating
- usable spectral range of the grating
- grating types
- transmission grating
- reflection grating
- echellette grating
- concave grating
- manufacturing techniques
- scored gratings
- holographic gratings
- Diffraction efficiency of gratings
- measurement
- Blaze Technique
- Comparison: grating and prism
- Structure of spectrometers
- Structure of the monochromator
- Structure of the prism spectrometer
- resolving capacity of the prism spectrometer
- beam path
- Structure of the grating spectrometer
- resolving capacity of the grating spectrometer
- beam path
- negative effects in the spectrometer
- ghost images
- scattered light
- Second Order Effects
- radiation sources
- Properties of radiation sources
- Thermal sources
- discharge lamps
- light-emitting diodes
- laser
- Detectors / Receivers
- Properties of Receivers
- photodiode
- CCD / CMOS line / matrix
- thermal detectors
- filters
- absorption filter
- interference filters
- Calibration of spectrometers

- wavelength calibration
- intensity calibration
- Characteristics of spectrometers
 - Spectral resolution capability
 - diffraction efficiency
 - free spectral range
- Commercial spectrometers
 - UV spectrometer
 - VIS spectrometer
 - IR / NIR spectrometer
 - Multichannel Spectrometer
- Fourier spectroscopy
 - Principle of Fourier Spectroscopy
 - Fourier transform
 - Discrete Fourier transformation
 - Fourier spectrometer
- applications
 - Raman spectroscopy
 - fundamentals
 - Applications of Raman spectroscopy
 - colorimetry
 - transmission measurement
 - remission measurement
 - emission measurement
 - coating thickness measurement
 - Spectral Element Analysis
 - (further topics according to selection)
- calculate
 - the spectral resolution
 - angular and linear dispersion
 - of the free spectral range
 - the working range of the chromatic longitudinal aberration sensor
 - the resolution of the light section sensor
- select
 - a spectrometer for a special measuring task
 - a light source for absorption and transmission measurements
- determine
 - the transmission curve of various optical components
 - the spectral reflectance
 - the thickness of non-opaque layers
- assess
 - the sensitivity of a spectrometer
 - the usability of a spectrometer
- analyze
 - of measuring tasks from the field of optical spectroscopy

Project

- Adjusting spectrometer superstructures
- record, evaluate and document optical spectra
- Check results for plausibility
- Recognizing and understanding interrelationships
- Selecting the spectrometer type for a specific measurement task

Calculation of the different spectral display modes

analyse a spectroscopic optical measuring task

Independently recognized measuring task can be analyzed

a given measuring task can be analyzed

design a solution approach for the analyzed optical measuring task

Consideration of laboratory resources

Consideration of the available time quota

Presentation of a project outline

Describe the task

outline the approach

Present results in a clearly structured way

Discuss results in technical and scientific manner

Milestone presentation to check the progress of the project

Describe the task

outline the approach

Present results in a clearly structured way

Discuss results in technical and scientific manner

Final presentation with presentation of the realized solution approach

Describe the task

outline the approach

Present results in a clearly structured way

Discuss results in technical and scientific manner

basic spectrometer setups can be realized by yourself

build

adjust

Carry out function test

investigate scientific/technical principles with an optical structure

Plan measurement series

Estimate error influences

Check the suitability of the superstructure

Evaluate self-acquired measurement series

Graphic display of measured values

Calculate implicit quantities from measured values math.

correctly

discover and name logical errors

Simulate measured values using predefined formulas

Work on complex technical tasks in a team

Organize into subtasks

Discuss measurement results

complement each other meaningfully

Teaching and Learning ■ Lecture
Methods ■ Project

Examination Types with ■ accompanying: project work [ungraded] and
Weights ■ final: oral examination [100%]

Workload 150 Hours

Contact Hours 34 Hours $\pm$ 3 SWS

Self-Study 116 Hours

Recommended Geometric optics
Prerequisites radiometry, photometry, radiation physics
Optical metrology
wave optics
Mathematics 1 / 2
Physics 1 / 2

Mandatory Prerequisites	▪ Project requires attendance in the amount of: 3 Projektpräsentationen ▪ Participation in final examination only after successful participation in Project
Recommended Literature	▪ Demtröder, Laser-Spektroskopie, Springer ▪ Demtröder, Experimentalphysik 2, Springer ▪ Schmidt Werner, Optische Spektroskopie, Wiley-VCH ▪ Pedrotti, Pedrotti, Bausch, Schmidt, Optik für Ingenieure, Grundlagen, Springer ▪ Schröder, Treiber, Technische Optik, Vogel Verlag ▪ Hecht, Optik, Oldenbourg ▪ Bergmann, Schaefer, Bd.3, Optik, de Gruyter ▪ Max Born und Emil Wolf, Principles of Optics, Cambridge University Press
Use of the Module in Other Study Programs	OSA in Master Elektrotechnik 2020
Specifics and Notes	
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6.20 PLET - Projektleitung

Module ID	PLET_MaET2024
Module Name	Projektleitung
Type of Module	Mandatory Module
Recognized Course	PLET - Project management
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Michael Gartz/Professor Fakultät IME
Lecturer(s)	▪ Prof. Dr. Michael Gartz/Professor Fakultät IME ▪ Prof. Dr. Uwe Oberheide/Professor Fakultät IME

Learning Outcome(s)

Was: Die Studierenden haben organisatorische Kompetenz erworben und können Projekt planen, durchführen, dokumentieren, Produktanforderungen analysieren, Machbarkeit bewerten und Produktqualität planen. Sie können Projektstrukturpläne und Projektzeitpläne erstellen, Projektmeilensteine planen, Projektrisiken erkennen und mildern. Sie können den Einsatz von Personal und Sachressource planen, Reviews planen, Produktverifikation planen.

Die Studierenden haben Projektführungskompetenz erworben und können die Projektsteuerung mit agilen, evolutionären Vorgehensmodellen und dem Timeboxmodell durchführen. Sie können Projektmanagementwerkzeuge einsetzen, den Projektfortschritt überwachen / steuern und Projektergebnisse freigeben. Sie können den Entwicklungsprozess fortlaufend optimieren in unklaren Situationen entscheiden. Sie können den Entwicklungsverlauf dokumentieren, Projektberichte verfassen und verteidigen.

Die Studierenden haben Personalführungskompetenz erworben und können Aufgaben auf Teammitglieder nach individuellen Qualifikationen und Neigungen verteilen.

Sie können die Teambildung fördern, das Team koordinieren und zielorientiert und respektvoll kommunizieren und verbindliche Absprachen treffen und einfordern. Sie können Teamprozesse moderieren, potenzielle Konfliktsituationen erkennen und auflösen und Handlungsalternativen abwägen.

Womit: indem sie die in dem Teamleiter Seminar erlernten Kompetenzen und Fertigkeiten und die in dem Projektleiter-Workshop erlernten Projektleitungs-Tools und Kompetenzen anwenden.

Wozu: um später in den verschiedensten Industriebereichen Projekte mittels agilen, evolutionären Vorgehensmodellen, wie z.B. SCRUM, zu planen, durchzuführen, zu managen und zum Erfolg zu bringen.

Module Contents

Seminar

Classifying and delimiting terms
explain characteristic properties of development projects
Goal orientation and innovation
Risk of failure
Special organisational form (teamwork)
Limited resources
Limited realization time
abstractly define technical and economic goals in development projects
abstractly define, explain and justify project management tasks
identify and explain basic success and failure factors in project management
unexpected technical problems
insufficient staff qualification
unclear or conflicting requirements
poor project management
Insufficient support from senior management
identify extended challenges arising from a division of labour in project processing
explain selected process models
linear models for business project management
phase model
V-model
agile process models for technical project management
SCRUM
timebox model
classify and compare process models with regard to development duration, organizational aspects, quality and cost aspects
professional quality control
Cost and schedule control in business management
Legal requirements for documentation and traceability of project decisions
characterize basic tasks and expected results in development projects
Planning and control of product quality
Planning and controlling the quality of the development process
overarching legal requirements
industry-specific specifications
company-internal specifications
project risk management
resource management
Documentation of the development process
Specification of the requirements for the product to be developed
Specification of the product design
Product development and manufacturing
product documentation
Verification and validation of the developed product
Product release and product monitoring
Characterize instruments for controlling team processes
plan essential management tasks, milestones and project documents with regard to the course element "Project
carry out essential management tasks mentally and identify project risks with foresight
handle essential project management tools in a target-oriented manner
for project (time) planning
for requirement specifications
Planning team building procedures, deriving expected challenges and meaningful measures

identify potential conflict situations in the team and discuss alternative actions

Project

Lead team

explain to the team members the basic procedure in the project

Capturing and classifying the competencies of team members

agree on goals in terms of content and deadlines

Project management

derive requirements specification in the team from the project order

and prioritize requirements

Create and maintain project plan

Identify project risks and plan meaningful mitigation measures, e.g. early feasibility studies

Create and maintain project schedule

Rough planning of tasks

Plan process

Planning effort, appointments, rooms

Plan Project Reviews

apply agile process model in conjunction with Timebox model to ensure a minimal project success

Define a minimum goal that can be achieved by the team.

define extended goals for fast teams

Drafting a final project report

Document and evaluate results

Document and evaluate the project process

Lead team

Monitoring and controlling goal achievement

Coordinate collaboration between team members

Recognizing and resolving conflict situations within the team

Project management

Planning and managing project sections

plan tasks for the next phase of the project in detail

and assign them meaningfully to the team members

Plan and moderate content reviews with team

members

Evaluate project results in the team

Modify the project section plan and, if necessary, the

project plan according to the project procedure.

evaluate the approach of the current project phase

retrospectively and, if necessary, modify it for the next

project phase.

Document project sections

plan access to shared laboratory resources

computer

tools

special workstations and measuring stations

special test environments

Prepare project decisions in the team

Teaching and Learning

■ Seminar

Methods

■ Project

Examination Types with Weights

■ accompanying: project work [ungraded]

Workload 150 Hours

Contact Hours 23 Hours $\pm$ 2 SWS

Self-Study 127 Hours

Recommended Prerequisites	basic knowledge of project management basic experience as a member of project teams
Mandatory Prerequisites	▪ Project requires attendance in the amount of: 8 Termine ▪ Participation in final examination only after successful participation in Project
Recommended Literature	▪ Hans-D. Litke, „Projektmanagement, Methoden, Techniken, Verhaltensweisen, Evolutionäres Projektmanagement“, Hanser ▪ Ken Schwaber: Agiles Projektmanagement mit Scrum (Microsoft Press) ▪ Litke, Kunow, Schulz-Wimmer, „Projekt-Management“, Taschenguide , Haufe ▪ Stefan Kreiser, Skripte der Vorlesung Software Engineering f.d. Automatisierungstechnik: „Projektmanagement, Vorgehensmodelle“, ILIAS ▪ Stanley E.Portny, „Projektmanagement für Dummies“, Wiley ▪ Marcus Heidbrink, „Das Projektteam“, Haufe ▪ Video Tutorial für SCRUM: http://www.video2brain.com/de/videotraining/agile-softwareentwicklung-mit-scrum
Use of the Module in Other Study Programs	▪ PLET in Master Elektrotechnik 2020 ▪ PLET in Master Technische Informatik 2020 ▪ PLET in Master Informatik und Systems-Engineering 2024
Specifics and Notes	
Last Update	22.8.2025, 10:17:37

6.21 QEKS - Qualitätsgesteuerter Entwurf komplexer Softwaresysteme

Module ID	QEKS_MaET2024
Module Name	Qualitätsgesteuerter Entwurf komplexer Softwaresysteme
Type of Module	Elective Modules
Recognized Course	SEKM - Software Engineering by Components and Pattern
ECTS credits	5
Language	deutsch und englisch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Stefan Kreiser/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Stefan Kreiser/Professor Fakultät IME

Learning Outcome(s)

Studierende sind im Hinblick auf die Qualität eines Softwaresystems in der Lage:

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

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

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

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

Seminar

challenging seminar topics can be defined e.g. from the following or related subject areas

- reusable artifacts for building the architecture of distributed software systems,
- professional distribution architectures,
- Multiagent systems,
- special economic, liability and ethical requirements for software systems with (distributed) artificial intelligence and their effects on the design of software architectures

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

Project

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

Teaching and Learning	▪ Lecture / Exercises
Methods	▪ Seminar
	▪ Project

Examination Types with	▪ accompanying: project work [ungraded] and
Weights	▪ final: oral examination [100%]

Workload	150 Hours
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Contact Hours	57 Hours $\pm$ 5 SWS
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Self-Study	93 Hours
Recommended Prerequisites	▪ Modul PLET: oder aus einem (naturwissenschaftlich-technischen) Bachelorstudium: - grundlegende Kenntnisse in (agilem) Projektmanagement ▪ - programming skills in an object-oriented programming language, preferably C++ ▪ - knowledge of software modeling using Unified Modeling Language (UML) or other (formal) languages that support modeling of interfaces, behavior and structures ▪ - basic knowledge in (agile) project management, SCRUM oder XP ▪ - basic knowledge of essential software architectural models ▪ - basic knowledge of interconnection models in software systems (OSI, TCP/IP, Messaging)
Mandatory Prerequisites	▪ Project requires attendance in the amount of: 3 Termine ▪ Participation in final examination only after successful participation in Project
Recommended Literature	▪ D. Schmidt et.al.: Pattern-Oriented Software Architecture. Patterns for Concurrent and Networked Objects (Wiley) ▪ Gamma et.al.: Design Patterns, (Addison-Wesley) ▪ Martin Fowler: Refactoring, Engl. ed. (Addison-Wesley Professional) ▪ U. Hammerschall: Verteilte Systeme und Anwendungen (Pearson Studium) ▪ Andreas Andresen: Komponentenbasierte Softwareentwicklung m. MDA, UML2, XML (Hanser Verlag) ▪ T. Ritter et. al.: CORBA Komponenten. Effektives Software-Design u. Progr. (Springer) ▪ Bernd Oestereich: Analyse und Design mit UML 2.5 (Oldenbourg) ▪ OMG Unified Modeling Language Spec., www.omg.org/um ▪ I. Sommerville: Software Engineering (Addison-Wesley / Pearson Studium) ▪ K. Beck: eXtreme Programming (Addison-Wesley Professional) ▪ Ken Schwaber: Agiles Projektmanagement mit Scrum (Microsoft Press)
Use of the Module in Other Study Programs	▪ QEKS in Master Elektrotechnik 2020 ▪ QEKS in Master Technische Informatik 2020 ▪ QEKS in Master Informatik und Systems-Engineering 2024
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.22 QM - Quantenmechanik

Module ID	QM_MaET2024
Module Name	Quantenmechanik
Type of Module	Elective Modules
Recognized Course	QM - Quantum mechanics
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Uwe Oberheide/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Uwe Oberheide/Professor Fakultät IME

Learning Outcome(s)

Die Studierenden besitzen ein Verständnis der Grundlagen quantenmechanischer Prozesse, indem sie anhand klassisch nicht erklärbarer Experimente die Entwicklung der Quantentheorie nachvollziehen und einfache, analytisch auswertbare Anwendungsfälle mathematisch beschreiben und auf reale Anwendungen der Elektrotechnik und Optik überführen, um in zukünftigen technischen Entwicklungen und Technologiefeldern Herausforderungen und Grenzen der Systeme einschätzen sowie wesentliche Strukturen im interdisziplinären Diskurs verstehen zu können.

Module Contents

Lecture

The failure of classical physics (black spot, photoelectric effect, Compton effect, Stern-Gerlach experiment, Bohr's atom model, matter waves)
 Quantum behaviour (experiments with spheres, waves and electrons; basic principles of quantum mechanics; principle of indeterminacy; laws of combination of amplitudes; identical particles)
 Schrödinger equation (development of the wave equation; stationary, time-dependent)
 simple potential problems (infinitely deep potential pot, finitely deep potential pot, potential stage, potential barrier, harmonic oscillator, hydrogen atom)
 Basic principles of quantum computers and quantum cryptography
 Description of given physical problems mathematically by listing the Schrödinger equation and applying of methods to solve the differential equations (separation approaches, limit value considerations)
 To evaluate physical solutions and select them by analogy
 Analyzing quantum effects and transferring them to technical applications

Seminar

Discourse on quantum mechanical processes (uncertainty principle, wave-particle dualism, wave functions/packages) and their applications in real systems in the context of the course

Teaching and Learning Methods

- Lecture
- Seminar

Examination Types with Weights

- accompanying: term paper [ungraded] and
- final: oral examination [100%]

Workload 150 Hours

Contact Hours 34 Hours $\pm$ 3 SWS

Self-Study 116 Hours

Recommended Prerequisites	In-depth knowledge of mathematics (integral calculus, differential calculus, vector geometry) Basic knowledge of physics (oscillations and waves, double slit, interference, thermodynamics, potential / kinetic energy) Basic knowledge of electrical engineering (magnetic and electric fields, components)
Mandatory Prerequisites	
Recommended Literature	▪ Harris – Moderne Physik, Pearson Verlag ▪ Feynman - Vorlesungen über Physik Band III:Quantenmechanik, Oldenbourg Verlag
Use of the Module in Other Study Programs	QM in Master Elektrotechnik 2020
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.23 RA - Reflexion Auslandssemester

Module ID	RA_MaET2024
Module Name	Reflexion Auslandssemester
Type of Module	Elective Modules
Recognized Course	RA - Reflection on the semester abroad
ECTS credits	6
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every term
Module Coordinator	Studiengangsleiter(in) Master Technische Informatik / Informatik und Systems-Engineering
Lecturer(s)	verschiedene Dozenten*innen / diverse lecturers
Learning Outcome(s)	Die Studierenden reflektieren kulturelle, gesellschaftliche und strukturelle Gemeinsamkeiten und Unterschiede ihrer Heimathochschule/-land und der Gasthochschule/-land. Sie werden dadurch in die Lage versetzt, bewusste Entscheidungen hinsichtlich ihrer zukünftigen akademischen und beruflichen Mobilität zu treffen. Die Studierenden reflektieren die persönlichen Erfahrungen, die sie während ihres Auslandssemesters gemacht haben, um ihr allgemeines Wertebewusstsein kritisch zu hinterfragen und ggf. zu justieren.
Module Contents	
Seminar	
	Students are able to reflect on cultural, social and structural similarities and differences between their home university/country and the host university/country. This enables them to make informed decisions regarding their future academic and professional mobility. Students can reflect on the personal experiences they have had during their semester abroad in order to critically question and, if necessary, adjust their general awareness of values.
Teaching and Learning Methods	Seminar
Examination Types with Weights	■ accompanying: oral contribution or term paper or learning portfolio [ungraded]
Workload	180 Hours
Contact Hours	12 Hours $\pm$ 1 SWS
Self-Study	168 Hours
Recommended Prerequisites	As a rule, a one-semester or longer period of study at a foreign university is a prerequisite for participation.
Mandatory Prerequisites	Seminar requires attendance in the amount of: 1 Termin
Recommended Literature	
Use of the Module in Other Study Programs	■ RA in Bachelor Elektrotechnik und Informationstechnik 2024 ■ RA in Bachelor Medientechnologie 2024 ■ RA in Bachelor Informatik und Systems-Engineering 2024 ■ RA in Master Communication Systems and Networks 2024 ■ RA in Master Medientechnologie 2024 ■ RA in Master Informatik und Systems-Engineering 2024
Specifics and Notes	This course is aimed exclusively at students who have completed a semester abroad.

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6.24 RFSD - RF System Design

Module ID	RFSD_MaET2024
Module Name	RF System Design
Type of Module	Elective Modules
Recognized Course	RFSD - RF System Design
ECTS credits	5
Language	englisch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Rainer Kronberger/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Rainer Kronberger/Professor Fakultät IME

Learning Outcome(s)

In general: Students will learn how high frequency components of wireless communication systems work

Module-specific:

students will get a general introduction in rf systems

they will learn in detail how transmitters and receivers in wireless communication systems work

they will learn in detail how the components of such systems (LNA, mixer, amplifier, oscillator, etc.) work

they will learn about limitation effects and noise in such systems

they will learn how to adapt the components to each other and how to plan and design the complete system (transmitter and / or receiver)

Module Contents

Lecture / Exercises

RF System, Applications

Noise in RF systems

noise classification and characterization

noise calculation

noise figure

noise matching

Linear and nonlinear circuit behaviour

theory

nonlinearities with mixers

nonlinearities with amplifiers

RF system components

receiver components

transmitter components

frequency generation

Lab

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Lab
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Examination Types with Weights	▪ accompanying: exercise lab [ungraded] and ▪ final: (digital) written exam or oral examination [100%]
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Workload	150 Hours
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Contact Hours	45 Hours $\pm$ 4 SWS
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Self-Study	105 Hours
Recommended Prerequisites	No formal requirements, but students should have knowledge in High Frequency and Microwave Topics
Mandatory Prerequisites	▪ Participation in final examination only after successful participation in Lecture / Exercises ▪ Lab requires attendance in the amount of: 3 Labortermine und 1 Präsentationstermin ▪ Participation in final examination only after successful participation in Lab
Recommended Literature	▪ Kraus & Carver Eletromagnetics, McGraw Hill, 2006. ▪ Michale Steer, Microwave and RF Design
Use of the Module in Other Study Programs	▪ RFSD in Master Communication Systems and Networks 2020 ▪ RFSD in Master Communication Systems and Networks 2024 ▪ RFSD in Master Medientechnologie 2024 ▪ RFSD in Master Informatik und Systems-Engineering 2024
Specifics and Notes	
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6.25 RM - Rastermikroskopie

Module ID	RM_MaET2024
Module Name	Rastermikroskopie
Type of Module	Elective Modules
Recognized Course	RM - Scanning Microscopy
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Stefan Altmeyer/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Stefan Altmeyer/Professor Fakultät IME

Learning Outcome(s)

Was:

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

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

Womit:

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

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

Wozu:

Vorbereitung auf eine selbständige, forschende Tätigkeit, sowohl fachlich als auch organsiatorisch. (HF1)

Anwendung tiefgreifende Fachkenntnisse im Bereich höchstauflösender Mess- und Analyseverfahren, die industriell als Mess- und Prüftechnologie zur Qualitätskontrolle von Produkten (HF2) eingesetzt werden, sowie Kompetenzvermittlung im Bereich der Überwachung von Produktionsprozessen (HF3)

Module Contents**Lecture / Exercises**

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

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

atomic force microscope
setup

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

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

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

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

Lab

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

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

interpretation of metrological findings

Teaching and Learning	▪ Lecture / Exercises
Methods	▪ Lab

Examination Types with Weights	▪ accompanying: exercise lab [ungraded] and ▪ final: oral examination [100%]
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Workload	150 Hours
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Contact Hours	45 Hours $\triangleq$ 4 SWS
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Self-Study	105 Hours
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Recommended Prerequisites	mathematics: differential- and integral calculus complex numbers vector calculus basics of differential geometry physics / optics: geometrical optics wave optics
Mandatory Prerequisites	▪ Lab requires attendance in the amount of: 5 Labortermine ▪ Participation in final examination only after successful participation in Lab
Recommended Literature	▪ Reimer: Scanning Electron Microscopy (Springer) ▪ Meyer, Hug, Bennewitz: Scanning Probe Microscopy (Springer) ▪ Wilhelm, Gröbler, Gluch, Heinz: Die konfokale Laser Scanning Mikroskopie (Carl Zeiss)
Use of the Module in Other Study Programs	RM in Master Elektrotechnik 2020
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.26 SIM - Simulation in der Ingenieurwissenschaft

Module ID	SIM_MaET2024
Module Name	Simulation in der Ingenieurwissenschaft
Type of Module	Mandatory Module
Recognized Course	FEM - Finite element method in electrical engineering
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Wolfgang Evers/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Wolfgang Evers/Professor Fakultät IME

Learning Outcome(s)

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

Module Contents

Lecture / Exercises

Discretisation of physical problems using the example of an electrostatic arrangement

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

Carry out and critically evaluate FEM simulations on various physical effects

Project

Teaching and Learning Methods	▪ Lecture / Exercises ▪ Project
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Examination Types with Weights	▪ accompanying: project work [100%]
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Workload	150 Hours
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Contact Hours	45 Hours $\pm$ 4 SWS
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Self-Study	105 Hours
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Recommended Prerequisites	- Electrostatic: field strength, flux density, dielectrics - Electromagnetism: field strength, flux density, flux, magnetic circuits, induced voltage
Mandatory Prerequisites	
Recommended Literature	■ Thomas Westermann, Modellbildung und Simulation ■ Thomas Westermann: Mathematik für Ingenieure
Use of the Module in Other Study Programs	SIM in Master Elektrotechnik 2020
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.27 SNEE - Stromnetze für erneuerbare Energien

Module ID	SNEE_MaET2024
Module Name	Stromnetze für erneuerbare Energien
Type of Module	Elective Modules
Recognized Course	SNEE - Electrical Power Grids for Renewable Energy
ECTS credits	5
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Eberhard Waffenschmidt/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Eberhard Waffenschmidt/Professor Fakultät IME

Learning Outcome(s)

Vor dem Hintergrund einer klima- und ressourcenschonenden Energiewende stehen unsere Stromnetze vor einem fundamentalen Wandel, der sich in den Zielen dieses Moduls widerspiegelt.

WAS: Die Studierenden erkennen die größten Herausforderungen an die elektrischen Verteilnetze und erarbeiten und bewerten Lösungsvorschläge.

WOMIT: Sie benennen die verschiedenen Netzformen, Komponenten und verwenden Fachbegriffe der elektrischen Netze. Sie berücksichtigen ihre Kenntnis der relevanten technischen und rechtlichen Vorgaben beim Anschluss von dezentralen Einspeisern an das Stromnetz. Sie kennen die verschiedenen Berechnungs-Methoden zur Analyse von elektrischen Netzen und wenden anwendungsbezogen die passende Methode an. Sie berücksichtigen die Grundlagen zur Steuerung und Regelung von elektrischen Netzen beim Einsatz von regelungstechnischen Berechnungsmethoden.

Aufbauend auf diesen Kompetenzen erstellen sie in Arbeitsgruppen Simulationsmodelle von elektrischen Netzen. Sie analysieren die Simulationsergebnisse anhand von vermittelten Rahmenbedingungen und bewerten die Ergebnisse anhand der selbst vorgegeben Ziele.

WOZU: Sie können später beurteilen, ob Stromnetze eines Netzbetreibers den zukünftigen Anforderungen genügen und sind in der Lage, einen sachgerechten Ausbau zu planen. Ferner können sie beurteilen, ob oder unter welchen Umständen ein Netzanschluss von dezentralen Einspeisern oder größeren Lasten möglich ist.

Module Contents**Lecture**

- The students name different grid topologies, components and are able to use terms related to electrical power grids.
 - They consider their knowledge of relevant technical and legal requirements for the connection of decentralized generators to the power grid.
 - They know different calculation methods for the analysis of electrical power grids and apply the suitable method for a particular problem.
 - They consider the basics for the control of electrical power grids using suitable control methods.
 - Summarizing it includes the following topics:
 - Grid topologies and components
 - Calculation and simulation of power grid
 - Fault management
 - Grid control
 - Gridconnection of decentralized generators
- Based on these competencies the students perform project works (see "Projektarbeit").

Project

Based on the knowledge of the lectures the students perform a project. They create simulation models of electrical power grids working in teams of 3 to 4 persons. They analyze the simulation results according to frame conditions and evaluate the results along self generated goals.

Project topics are:

Future loads of electrical power grids due to

- Photovoltaics
- Electromobility
- Electrical heat usage
- Electrical heat storages

under different requirements as e.g. settlement areas

- city
- suburban
- rural

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

Teaching and Learning Methods	▪ Lecture ▪ Project
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Examination Types with Weights	▪ accompanying: project work [60%] and ▪ final: oral examination [40%]
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Workload	150 Hours
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Contact Hours	34 Hours $\pm$ 3 SWS
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Self-Study	116 Hours
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Recommended Prerequisites	Basics of electrical Engineering, especially alternating current calculations with complex numbers and three phase systems
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Mandatory Prerequisites

Recommended Literature	■ Klaus Heuck, Klaus-Dieter Dettmann, Detlef Schulz, "Elektrische Energieversorgung", 7. vollständig überarbeitete und erweiterte Auflage, Vieweg Verlag, Wiesbaden, 2007. ISBN 978-3-8348-0217-0 ■ Dieter Nelles, Christian Tuttas, "Elektrische Energietechnik", B.G. Teubner Verlag, Stuttgart, 1998, ISBN 3-519-06427-8 ■ Valentin Crastan, "Elektrische Energieversorgung 1: Netzelemente, Modellierung, stationäres Verhalten, Bemessung, Schalt- und Schutztechnik", 2. bearbeitete Auflage, Springer Verlag, Berlin Heidelberg New York, 2007, ISBN 978-3-540-69439-7 ■ „Erzeugungsanlagen am Niederspannungsnetz – Technische Mindestanforderungen für Anschluss und Parallelbetrieb von Erzeugungsanlagen am Niederspannungsnetz“, VDE-Anwendungsregel VDE-AR-N 4105, Aug. 2011, verbindlich gültig ab 1.1.2012.
Use of the Module in Other Study Programs	SNEE in Master Elektrotechnik 2020
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.28 SYE - Systemtechnik für Energieeffizienz

Module ID	SYE_MaET2024
Module Name	Systemtechnik für Energieeffizienz
Type of Module	Elective Modules
Recognized Course	SYE - Systems Engineering for Energy Efficiency
ECTS credits	5
Language	deutsch, englisch bei Bedarf
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Johanna May/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Johanna May/Professor Fakultät IME
Learning Outcome(s)	
Bestehende und neuartige Systeme und Produkte systematisch auf energetische Optimierungspotenziale hin analysieren und daraus Verbesserungen für die Energieeffizienz ableiten, indem funktionelle Anforderungen in technische Kennzahlen übersetzt werden, messtechnische Verfahren angewandt und eigene sowie Werte aus der Literatur kritisch bewertet werden, starke Einflussparameter ermittelt werden, Kreativitätsmethoden angewendet werden, mit starken Einflüssen Funktionsmodelle simuliert werden und die Sichtweisen verschiedener Stakeholder berücksichtigt werden, um später im Beruf damit neuartige Systeme energieeffizienter konzipieren zu können oder bei bestehenden Systemen Anhaltspunkte zur Verbesserung der Energieeffizienz zu ermitteln.	
Module Contents	
Lecture / Exercises	
electrical power measurements and thermography (lab), analyse load profiles and simulation in python, use relevant standards for evaluation of energy payback time, economic viability and life cycle analysis, overview over most frequenz energy efficiency measures (pressurized air, lighting, heat recovery)	
translate functional requirements on systems and products into technical key parameters and document knowlegde, apply measurements and critically evaluate own and data from literature, find influencing factors, use creativity methods, simulate strong influence factors in functional models and evaluate potentials for improvement quantitatively, evaluate acceptance from different viewpoints	
Lab	
thermography, measurement of electrical energy of more or less energy efficient consumers, measure electrical load profiles (at home), critical evaluation of measurement uncertainty	
Project	
apply methods of lecture to a specific (every semester newly conceived) project topic in the area of energy efficiency, work in a team	
Teaching and Learning Methods	■ Lecture / Exercises ■ Lab ■ Project
Examination Types with Weights	■ accompanying: project work [50%] and ■ final: oral examination [50%]
Workload	150 Hours
Contact Hours	57 Hours $\pm$ 5 SWS
Self-Study	93 Hours

Recommended Prerequisites	Bachelor electrical engineering, renewable energy or comparable
Mandatory Prerequisites	▪ Project requires attendance in the amount of: 5 Projektermine, Präsentation, mündliche Prüfung ▪ Participation in final examination only after successful participation in Project
Recommended Literature	▪ M. Pehnt: Energieeffizienz: Ein Lehr- und Handbuch, Springer, 1. korrigierter Nachdruck 2010, ISBN 9783642142512 ▪ M. Günther: Energieeffizienz durch Erneuerbare Energien: Möglichkeiten, Potenziale, Systeme, Springer Fachmedien Wiesbaden, 2015, ISBN 9783658067533 ▪ F. Wosnitza, H.G. Hilgers: Energieeffizienz und Energiemanagement: Ein Überblick heutiger Möglichkeiten und Notwendigkeiten, Vieweg + Teubner Verlag, 2012, ISBN 9783834886712 ▪ J. Hesselbach: Energie- und klimateffiziente Produktion: Grundlagen, Leitlinien und Praxisbeispiele, Vieweg + Teubner Verlag, 2012, ISBN 9781280786358 ▪ Recherche über scopus, Webinare der EU (leonardo)
Use of the Module in Other Study Programs	SYE in Master Elektrotechnik 2020
Specifics and Notes	
Last Update	19.7.2025, 14:32:16

6.29 TED - Theoretische Elektrodynamik

Module ID	TED_MaET2024
Module Name	Theoretische Elektrodynamik
Type of Module	Mandatory Module
Recognized Course	TED - Theoretical Electro Dynamics
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	2
Frequency of Course	every summer term
Module Coordinator	Prof. Dr. Holger Weigand/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Holger Weigand/Professor Fakultät IME

Learning Outcome(s)

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

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

Module Contents**Lecture / Exercises**

Introduction into Electro Dynamics
 Charges, currents
 Forces, fields
 Classical Electro Dynamics
 Electrostatics
 Field, potential
 Polarization
 Electrostatic energy
 Capacity
 Multi pole development
 Interaction of charge distributions
 Stationary electrical field
 Magnetostatics
 Stationary magnetical field
 Vector potential
 Magnetization
 Magnetostatic energy
 Inductivity
 Quasi stationary electromagnetic fields
 Induction effects
 Skin effect
 Rapidly changing electromagnetic fields
 Electromagnetic waves
 Reflection and diffraction
 Knowledge of meaning of Maxwell- and material equations
 Derivation of electric/magnetic potential/field from charge/current distributions
 Development of potential / field to monopole, dipole, quadrupole and higher moments
 Calculation of capacity/inductivity to charge/current distributions from energy balance
 Derivation of Continuity equation, Kirchhoff Laws from Maxwell equations
 Derivation and solving of diffusion/wave equations from Maxwell equations
 Solving of macroscopic problems by integration of microscopic/differential description
 Solving of training examples

Teaching and Learning Lecture / Exercises**Methods**

Examination Types with Weights ■ final: (digital) written exam or oral examination [100%]

Workload 150 Hours**Contact Hours** 34 Hours $\pm$ 3 SWS**Self-Study** 116 Hours**Recommended Prerequisites** Vector analysis**Mandatory Prerequisites**

Recommended Literature ■ Lehner: "Elektromagnetische feldtheorie für Ingenieure", Springer-Verlag
 ■ Wunsch: "Elektromagnetische Felder", Verlag technik

Use of the Module in Other Study Programs TED in Master Elektrotechnik 2020

Specifics and Notes

Last Update

19.7.2025, 14:32:16

6.30 ZR - Zustandsregelung

Module ID	ZR_MaET2024
Module Name	Zustandsregelung
Type of Module	Elective Modules
Recognized Course	ZR - State Space Control
ECTS credits	5
Language	deutsch
Duration of Module	1 Semester
Recommended Semester	1-2
Frequency of Course	every winter term
Module Coordinator	Prof. Dr. Norbert Große/Professor Fakultät IME
Lecturer(s)	Prof. Dr. Norbert Große/Professor Fakultät IME

Learning Outcome(s)

- Digitale Regler (Einsatzgründe, Funktionsweise, Abtastzeiten)
- Differenzengleichungen
- z-Transformation
- Stabilität, Regelverhalten in Abhängigkeit der Pole
- Zustandsraum im Zeitkontinuierlichen
- Normalformen, Transformation der Zustandsraumdarstellung
- Steuerbarkeit, Beobachtbarkeit
- Reglerentwurf nach Polvorgabe
- Vorfilter, Kompensator
- Beobachterentwurf nach Polvorgabe
- Optimaler Reglerentwurf
- Zustandsraum im Zeitdiskreten

Module Contents**Lecture / Exercises**

- | Sampling, quantization describe
- | describe time-discrete systems in the time domain
- | Describe time-discrete systems in the frequency domain
- | Analyze the stability and position of the poles of the transfer function
- | state space description of a system
- | Describe time-continuously
- | Describe time-discretely
- | Transform to normal forms
- | Determine stability, controllability, observability
- | Design state space controller according to pole assignment
- | Design optimal state space controller
- | Prefilter and noise compensation design
- | Design of observers with pole placement
- | Design of optimal observers
- | Create models from a physical perspective
- | Select suitable state variables
- | Perform simulation of dynamic systems

Project

- | Use spreadsheet programs for difference equations
- | Use matrix calculation programs
- | Perform simulation of dynamic systems
- | Review design of complex dynamic systems

Teaching and Learning Methods

- Lecture / Exercises
- Project

Examination Types with Weights

- accompanying: project work [ungraded] and
- final: (digital) written exam or oral examination [100%]

Workload 150 Hours

Contact Hours 45 Hours $\pm$ 4 SWS

Self-Study 105 Hours

Recommended Prerequisites Basics of control engineering
differential equations, Laplace transformation, frequency domain;
Matrix calculation

Mandatory Prerequisites

Recommended Literature

- Taschenbuch der praktischen Regelungstechnik, Große, Schorn, Hanser Verlag

Use of the Module in Other Study Programs ZR in Master Elektrotechnik 2020

Specifics and Notes

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7. Electives Catalogs

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

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

Stays abroad

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

7.1 BTH - Beliebige Modul aus einem Masterstudiengang der TH Köln

Beliebige Modul aus einem Masterstudiengang der TH Köln

You must select modules of 5 ECTS credit points in total out of this catalog.

7.2 SV - Studienschwerpunktmodule

You must select modules of 15 ECTS credit points in total out of this catalog.

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

- Specialization AU - Automatisierungstechnik
- Specialization ET - Elektrische Energietechnik
- Specialization OT - Optische Technologien

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

Modules of the faculty:

Module ID	Module Name	ECTS	included in Specialization
CSO	Computersimulation in der Optik	5	OT
DMC	Digital Motion Control	5	AU
EMM	Energiemanagement in Energieverbundsystemen	5	ET
HSUT	Hochspannungsübertragungstechnik	5	ET
NLO	Nichtlineare Optik	5	OT
QEKs	Qualitätsgesteuerter Entwurf komplexer Softwaresysteme	5	AU
QM	Quantenmechanik	5	OT
SNEE	Stromnetze für erneuerbare Energien	5	ET
SYE	Systemtechnik für Energieeffizienz	5	ET
ZR	Zustandsregelung	5	AU

7.3 WM - Allgemeiner Wahlmodulbereich

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

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

- Electives Catalog SV - Studienschwerpunktmodule

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

Modules of the faculty:

Module ID	Module Name	ECTS	included in Specialization
ACC	Advanced Channel Coding	5	
BSN	Fundamentals of System and Network Theory	5	
CSO	Computersimulation in der Optik	5	OT
DLO	Deep Learning und Objekterkennung	5	
DMC	Digital Motion Control	5	AU
DSP	Digital Signal Processing	5	
EBA	Elektrische Bahnen	5	
EFA	Elektrische Fahrzeugantriebe	5	
EMM	Energiemanagement in Energieverbundsystemen	5	ET
ERMK	Entrepreneurship, Gewerblicher Rechtsschutz, Market Knowledge	5	
ESD	Embedded Systems Design	5	
HSUT	Hochspannungsübertragungstechnik	5	ET
IBD	InnoBioDiv	5	
ITF	IT-Forensik	5	
LCSS	Large and Cloud-based Software-Systems	5	
LSPW	Leistungselektronische Stellglieder für PV- und Windkraftanlagen	5	
MLWR	Maschinelles Lernen und wissenschaftliches Rechnen	5	
NGN	Next Generation Networks	5	
NLO	Nichtlineare Optik	5	OT
OSA	Optische Spektroskopie und Anwendungen	5	
QEKs	Qualitätsgesteuerter Entwurf komplexer Softwaresysteme	5	AU
QM	Quantenmechanik	5	OT
RFSD	RF System Design	5	
RM	Rastermikroskopie	5	
SNEE	Stromnetze für erneuerbare Energien	5	ET
SYE	Systemtechnik für Energieeffizienz	5	ET
VAE	Virtual Acoustic Environments	5	
ZR	Zustandsregelung	5	AU

8. Specializations

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

- A major field of study is considered successfully completed if the modules listed therein, comprising at least 15 ECTS, have been successfully completed.
- At least one major field of study must be completed.
- The completed areas of specialization are listed in a separate appendix to the degree certificate; if there is more than one, only parts of it may be listed upon request to the Examination Office.
- Upon request, a major field of study can be supplemented with additional suitable modules. Such a request must be submitted informally to the program director at least six months before planned participation in a module to be supplemented. The examination board decides on the acceptance of the request in consultation with the program director and appropriately qualified teaching staff.

8.1 AU - Automatisierungstechnik

Modules of the faculty:

Module ID	Module Name	ECTS
DMC	Digital Motion Control	5
QEKs	Qualitätsgesteuerter Entwurf komplexer Softwaresysteme	5
ZR	Zustandsregelung	5

8.2 ET - Elektrische Energietechnik

Modules of the faculty:

Module ID	Module Name	ECTS
EMM	Energiemanagement in Energieverbundsystemen	5
HSUT	Hochspannungsübertragungstechnik	5
SNEE	Stromnetze für erneuerbare Energien	5
SYE	Systemtechnik für Energieeffizienz	5

8.3 OT - Optische Technologien

Modules of the faculty:

Module ID	Module Name	ECTS
CSO	Computersimulation in der Optik	5
NLO	Nichtlineare Optik	5
QM	Quantenmechanik	5

9. Examination Types

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

(Digital) Written exam

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

Oral examination

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

Oral contribution

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

Technical discussion

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

Project work

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

Lab report

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

Exercise lab

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

Exercise lab under examination conditions

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

Term paper

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

Learning portfolio

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

Single / Multiple choice

See §20 of the examination regulations.

Access colloquium

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

(Intermediate) Certificate

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

Open book preparation

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

Thesis

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

Colloquium

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

10. Profile Module Matrix

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

Abbr.	Module Name	HF1 - Entwicklung und Design	HF2 - Forschung und Innovation	HF3 - Leitung und Management	HF4 - Qualitätssicherung und Te...	K.1 - Entwicklung und Konzeptio...	K.2 - Prüfung und Bewertung kom...	K.3 - Wissenschaftliches Arbeit...	K.4 - Projektmanagement und Tea...	K.5 - Selbstorganisation und au...	K.6 - Kommunikation und interku...	K.7 - Technische und naturwisse...	K.8 - Nachhaltigkeit und gesell...	K.9 - Analyse, Simulation und A...	K.10 - Führungs- und Entscheidun...	K.11 - Anwendung ethischer Werte...	K.12 - Integratives Denken und H...	K.13 - Innovation und Kreativität...	SK.1 - Global Citizenship	SK.2 - Internationalisierung	SK.3 - Interdisziplinarität	SK.4 - Transfer
CSO	Computersimulation in der Optik	●	●	●	●	●	●	●		●	●	●		●	●			●				
DLO	Deep Learning und Objekterkennung	●	●		●	●	●	●	●		●			●		●						
DMC	Digital Motion Control	●	●		●	●	●			●	●	●	●	●		●	●					
EBA	Elektrische Bahnen	●	●		●	●	●	●		●	●		●	●				●				
EFA	Elektrische Fahrzeugantriebe	●	●	●	●	●	●	●		●			●	●				●				
EMM	Energiemanagement in Energieverbundsystemen		●	●			●	●	●	●	●	●	●	●	●		●					
ERMK	Entrepreneurship, Gewerblicher Rechtsschutz, Market Knowledge																					
ESD	Embedded Systems Design	●				●	●		●	●	●	●		●				●		●	●	●
FS	Forschungsseminar	●	●	●	●		●	●		●	●		●	●	●							
HIM	Advanced Mathematics				●		●	●						●						●		
HSUT	Hochspannungsübertragungschnik	●	●		●	●	●	●		●	●		●	●				●				
IBD	InnoBioDiv					●	●	●		●	●	●						●	●	●	●	●
ITF	IT-Forensik	●			●	●	●	●	●	●				●	●		●	●				
KOLL	Kolloquium zur Masterarbeit	●	●	●	●					●	●											
LSPW	Leistungselektronische Stellglieder für PV- und Windkraftanlagen	●	●	●	●	●	●	●		●			●	●				●				

Abbr.	Module Name	HF1 - Entwicklung und Design	HF2 - Forschung und Innovation	HF3 - Leitung und Management	HF4 - Qualitätssicherung und Te...	K.1 - Entwicklung und Konzeptio...	K.2 - Prüfung und Bewertung kom...	K.3 - Wissenschaftliches Arbeit...	K.4 - Projektmanagement und Tea...	K.5 - Selbstorganisation und au...	K.6 - Kommunikation und interku...	K.7 - Technische und naturwisse...	K.8 - Nachhaltigkeit und gesell...	K.9 - Analyse, Simulation und A...	K.10 - Führungs- und Entscheidun...	K.11 - Anwendung ethischer Werte...	K.12 - Integratives Denken und H...	K.13 - Innovation und Kreativität...	SK.1 - Global Citizenship	SK.2 - Internationalisierung	SK.3 - Interdisziplinarität	SK.4 - Transfer
MAA	Masterarbeit	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●			●	●
MLWR	Maschinelles Lernen und wissenschaftliches Rechnen							●		●			●	●		●	●	●			●	●
NLO	Nichtlineare Optik	●	●	●	●		●	●		●	●	●		●								
OSA	Optische Spektroskopie und Anwendungen	●	●	●	●	●	●	●	●	●	●	●		●	●		●	●				
PLET	Projektleitung	●	●	●	●			●	●		●		●		●	●	●		●		●	
QEKS	Qualitätsgesteuerter Entwurf komplexer Softwaresysteme	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●				
QM	Quantenmechanik		●		●	●	●			●	●	●		●				●				
RA	Reflexion Auslandssemester																	●	●	●		
RFSD	RF System Design		●		●	●	●	●			●			●				●		●	●	
RM	Rastermikroskopie	●	●		●		●	●	●	●	●	●		●			●					
SIM	Simulation in der Ingenieurwissenschaft	●	●	●	●	●		●	●	●				●	●		●	●				
SNEE	Stromnetze für erneuerbare Energien	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●				
SYE	Systemtechnik für Energieeffizienz	●	●	●	●		●	●	●		●		●	●	●		●					
TED	Theoretische Elektrodynamik		●					●			●	●		●								
ZR	Zustandsregelung	●	●		●	●	●	●		●		●		●				●				

11. Version History

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

Version	Date	Changes	Link
1.1	2025-06-24-18-55-09	1. Reakkreditierte Version	Link
1.0	2024-12-06-08-45-55	1. Begutachtete Version für Reakkreditierung 2024 2. Neues Layout für sämtliche Modulhandbücher	Link

Impressum

Datenschutzhinweis

Haftungshinweis

Bei Fehlern, bitte Mitteilung an
die
[modulhandbuchredaktion@f07.th-
koeln.de](mailto:modulhandbuchredaktion@f07.th-koeln.de)