Karlsruher Institut für Technologie

Module Handbook
M.Sc. Electrical Engineering and Information Technology Master 2025 (Master of Science)

SPO 2025

Summer term 2025

Date: 20/12/2024

KIT DEPARTMENT OF ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY

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1 Preamble

1.1 Foreword to the technical implementation

This is a preliminary draft of the module handbook for the Master's degree program in Electrical Engineering and Information Technology.

As the Master's degree program in Electrical Engineering and Information Technology has not been fully mapped in the CAMPUS management system, at this time a complete module handbook and is not yet possible.

Some modules may be added to the lists and in the elective subjects some may be deleted.
The final module handbook will be published on March, 11th 2025.

1.2 Overview of the degree program

The Master's degree program in Biomedical Engineering at the Karlsruhe Institute of Technology (KIT) is divided into the four subjects:

- Field of Specialization (60 CP)
  - Fundamentals (24 CP)
  - Focus Area (dependet on Lab: 27-30 CP)
  - Lab course (exactly 1)
- Electives (24 CR)
- Interdisciplinary Qualification Area (6 CR)
- Master’s Thesis (30 CR)

Fields of Specialization

One of the four “Fields of Specialization” can be chosen.

- Automation, Robotics & Systems Engineering
- Electrical Power Systems and Electromobility
- Information and Communication Technology
- Microelectronics, Photonics and Quantum Technologies

Within each “Fields of Specialization” four modules of the subject “Fundamentals” has to be chosen.

Furthermore, there are several “Focus Areas” that provide the students an orientation and recommendation for possible study courses and thus a guideline of reasonable module combinations. They are shown in the following chapter.

At last, exactly one lab or practical course has to be chosen within each “Field of Specialization”.

Master Electrical Engineering and Information Technology (SPO 2025)

<table>
<tr><th>Credits</th><th>1st term</th><th>2nd term</th><th>3rd term</th><th>4th term</th></tr>
<tr><td></td><td>Fundamentals Module 1 (6 LP, 4 SWS)</td><td>Fundamentals Module 3 (6 LP, 4 SWS)</td><td rowspan="4">Electives (24 CP)</td><td rowspan="5">Master's Thesis (30 CP)</td></tr>
<tr><td>10 CP</td><td>Fundamentals Module 2 (6 LP, 4 SWS)</td><td>Fundamentals Module 4 (6 LP, 4 SWS)</td></tr>
<tr><td></td><td>Fundamentals/ Focus Area Module (6 CP)</td><td>Lab Course* (6 CP)</td></tr>
<tr><td>20 CP</td><td rowspan="2">Focus Area Modules (12 CP)</td><td rowspan="2">Focus Area Modules (12 CP)</td></tr>
<tr><td>30 CP</td><td>Interdisciplinary Qualifications (6 CP)</td></tr>
</table>

*** Lab Course: the credits may vary and are compensated in the Focus Area**

Subjects

<table>
<tr><td>Fundamentals</td><td>24 or 30 CP</td><td rowspan="3">Field of Specialization: in sum 60 CP</td></tr>
<tr><td>Focus Area</td><td>min. 24 CP</td></tr>
<tr><td>Lab Course</td><td>1 course</td></tr>
<tr><td>Electives</td><td colspan="2">24 CP</td></tr>
<tr><td>Interdisciplinary Qualifications</td><td colspan="2">6 CP</td></tr>
<tr><td>Master's Thesis</td><td colspan="2">30 CP</td></tr>
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Field of Specialization: Automation, Robotics & Systems Engineering

Fundamentals (24 CP)	CP winter	CP summer	Automation, Control & Robotics (Barth, Hohmann)	Measurement, Sensing & Signal-Processing (Heizmann, Wahls, Zwick)	Systems Engineering (Sax)
English modules					
Cyber-Physical Modeling		6	x		
Optical Engineering and Machine Vision	6			x	
Optimization of Dynamic Systems	6		x		
Robotics & Sensing (starts April 2026)		6	x	x	
Signal Processing Methods	6			x	
Systems and Software Engineering	6				x
Focus Area (dependet on Lab: 27-30 CP)	**CP winter**	**CP summer**			
English modules					
Communication Systems and Protocols		5	x		x
Cyber Security	4		x	x	x
Digital Twin Engineering	4		x		x
Hardware Modeling and Simulation	4				x
Hardware/Software Co-Design	4				x
Hardware-Synthese und -Optimierung		6			x
Industrial Process and Plant Engineering		6	x		x
Laser Metrology		3		x	
Multivariable Control Systems	6		x		
Navigation and Localization Techniques		3	x	x	
Nonlinear Control Systems		6	x		
Prozessanalyse: Modellierung, Data Mining, Machine Learning		3	x	x	
Radar Systems Engineering	6		x	x	
Signal processing using nonlinear Fourier transforms and Koopman operators		6		x	
Software Engineering		3			x
Spaceborne Radar Remote Sensing		6		x	
Student Innovation Lab (combined with course in "Lab Course" below)	9		x	x	x
Systems Engineering for Automotive Electronics		4			x
German modules					
Informationsfusion	4		x	x	x
Informationstechnik in der Industriellen Automation		3	x		
Praktisches Machine Learning		5		x	
Projektmanagement in der Entwicklung von Produkten für sicherheitskritische Anwendungen	4				x
Quantum Machine Learning	3			x	
Seminar eingebettete Systeme		4			x
Sensoren		3		x	

Test eingebetteter Systeme im industriellen Umfeld	4				x
Verteilte ereignisdiskrete Systeme	4		x	x	
Lab Course (exactly 1)	**CP winter**	**CP summer**			
English modules					
Seamless Engineering	9				x
Signal Processing Lab		6		x	
Student Innovation Lab (combined with course in "Focus Area" above)		6	x	x	x
German modules					
Labor Schaltungsdesign		6			x
Praktikum Entwurf Digitaler Systeme		6			x
Praktikum Mechatronische Messsysteme	6			x	
Praktikum Software Engineering		6			x
Praktikum System-on-Chip	6				

Field of Specialization: Electrical Power Systems and Electromobility

Fundamentals (24 CP)	CP winter	CP summer	Electro-mobility	Electric Drives	Power Electronic Systems	Renewables	Electro-chemical Systems	Power Systems Engineering & Economics	Super-conductor Engineering
English modules									
Batterien und Brennstoffzellen	6		x			x	x		
Electric Power Transmission and Grid Control		6	x		x	x		x	x
Numerical Methods		6	x	x	x	x	x	x	x
Optimization of Dynamic Systems	6		x	x	x	x	x	x	x
Power Electronics		6	x	x	x	x	x	x	x
Superconductivity for Engineers	6								x
Focus Area (30 CP)	**CP winter**	**CP summer**							
English modules									
Communication Systems and Protocols		5	x	x	x	x	x	x	
Components of Power Systems		3						x	
Electric Drives for E-Mobility		5	x	x	x		x		
Electrocatalysis		5					x		
Energy Storage and Network Integration	4				x	x	x		
Hardware/Software Co-Design	6		x	x					
Liberalised Power Markets	6					x		x	
Nano- and Quantum Electronics		6							x
Pulsed Power Technology and Applications	3								x
Quantum Detectors and Sensors	6								x
Radio-Frequency Electronics	5	5							x
Renewable Energy-Resources, Technologies and Economics	3					x		x	
Seminar on Applied Superconductivity		3							x
Solar Energy (winter term) or Photovoltaik (summer term)	6	6				x	x		
Solar Thermal Energy Systems	4					x			
Superconducting Magnet Technology		4							x
Superconducting Materials (2-term module)	3	3							x
Superconducting Power Systems	4								x
Systems and Software Engineering	6		x	x					
German modules									
Aufbau- und Verbindungstechnik für leistungselektronische Systeme	3			x	x				
Batterie- und Brennstoffzellensysteme		3	x		x	x	x		
Echtzeitregelung elektrischer Antriebe	6		x	x	x				
Einführung in die Energiewirtschaft		5						x	
Elektronische Systeme und EMV		3		x					
Energiewirtschaft	3							x	
Entwurf Elektrischer Maschinen	5		x	x					x
Grundlagen der Fahrzeugtechnik I	8		x						

Hochspannungsprüftechnik	4				x			x	
Hochspannungstechnik	6				x			x	
Leistungselektronik für die Photovoltaik und Windenergie		3			x	x	x	x	
Leistungselektronische Systeme in der Energietechnik	6			x	x	x	x	x	
Praxis elektrischer Antriebe	4		x	x					
Regelung leistungselektronischer Systeme		6	x	x	x	x	x	x	
Schaltungstechnik in der Industrieelektronik	3			x	x				
Schutz- und Leittechnik in elektrischen Netzen	3				x			x	
Seminar Elektrokatalyse	3	3					x		x
Seminar Neue Komponenten und Systeme der Leistungselektronik	4	4	x	x	x	x		x	
Stromrichtersteuerungstechnik	3			x	x	x			
Workshop Finite Elemente Methode in der Elektromagnetik		3		x					
Lab Course (exactly 1)	**CP winter**	**CP summer**							
English modules									
Lab Course on Nanoelectronics/Praktikum Nanoelektronik	6	6							x
Lab Course on Noise Thermometry	6	6							x
Lab Course on Robotic Winding Technology for Superconducting Wires	6								x
Lab Course on Superconducting Materials/ Praktikum Supraleitende Materialien	6	6							x
Lab Course on Superconducting Quantum Electronics/ Praktikum Supraleitende Quantenelektronik	6	6							x
Laboratory Modern Software Tools in Power Engineering		6						x	
Laboratory Information Systems in Power Engineering		6						x	
Laboratory Solar Energy/Praktikum Solarenergie	6	6				x			
Practical Course: Smart Energy System	6	6				x		x	
German modules									
Energietechnisches Praktikum	6			x	x				
Praktikum Batterien und Brennstoffzellen	6		x			x	x		
Praktikum Elektrische Antriebe und Leistungselektronik		6	x	x	x				

Field of Specialization: Information and Communication Technology

Fundamentals (24 CP)	CP winter	CP summer	Communication Systems (Schmalen, Rost, Zwick, Randel)	Communication Algorithms and Theory (Schmalen, Rost)	Signal and Information Processing (Wahls, Heizmann, Becker)	Microwave Systems (Zwick, Ulusoy, Younis)	Photonic Systems (Randel, Koos, Eichhorn)	Embedded System Integration (Becker)
English modules								
Advanced Communication Engineering	6		x	x	x	x	x	x
Hardware/Software Co-Design	6				x			x
Modern Radio Systems Engineering		6	x	x		x		
Numerical Methods		6	x	x	x	x	x	x
Optical Networks and Systems	6		x	x	(x)		x	
Signal Processing Methods	6		x	x	x	x	x	x
Focus Area (30 CP)	**CP winter**	**CP summer**						
English modules								
Antennas and Beamforming	4		x			x		
Applied Electromagnetics (starts October 2025)	4					x	x	
Channel Coding: Algebraic Methods for Communications and Storage		3		x				
Channel Coding: Graph-Based Codes	6		x	x				
Communication Systems and Protocols	5	5	x			x		x
Cyber-Physical Modeling		6						
Cyber Security	4		x					
Digital Signal Processing in Optical Communications		6	x		x		x	
Digital Twin Engineering	4							
Field Propagation and Coherence	4						x	
Hardware Modeling and Simulation	4							x
Industrial Process and Plant Engineering		6						
Integrated Photonics (comming soon)	6					x	x	
Machine Learning for Information and Communication Technology		6	x	x	x			
Mobile Communications	4		x	x				
Mobile Communications II		3						
Nonlinear Optics		6					x	
Optical Engineering and Machine Vision	6				x			
Optical Transmitters and Receivers	6						x	
Optoelectronic Components		4	x			x	x	
Photonic Integrated Circuits: Design and Applications		6					x	
Quantum Machine Learning	3				x			
Radar Systems Engineering	5					x		
Radio Frequency Integrated Circuits and Systems		6						
Radio-Frequency Electronics		6	x			x	x	

Robotics & Sensing		6						
Satellite Communications		3						
Seminar Embedded Systems	4	4						x
Signal processing using nonlinear Fourier transforms and Koopman operators		6	x	x	x		x	
Spaceborne Radar Remote Sensing		6						
German modules								
Angewandte Informationstheorie	6		x	x	x			
Funkempfänger (Jondral)	3			x				
Hardware-Synthese und -Optimierung		6						x
Informationsfusion	4		x	x	x	x		x
Integrierte Intelligente Sensoren		3						x
Mikrosystemtechnik	3							
Mikrowellenmesstechnik		4				x	x	
Praktisches Machine Learning		5			x			
Quellencodierung		3		x				
Seminar: Ausgewählte Kapitel der Nachrichtentechnik	4	4						
Signalverarbeitung in der Nachrichtentechnik		4	x	x	x	x	x	
Verteilte ereignisdiskrete Systeme	4							
Lab Course (exactly 1)	**CP winter**	**CP summer**						
English modules								
Communications Engineering Laboratory/Praktikum Nachrichtentechnik	6	6	x	x			x	
Digital Hardware Design Lab		6	x				x	x
Microwave Engineering Lab	6	6	x			x	x	
MMIC Design Laboratory	6	6				x	x	
Photonics and Communications Lab		6	x				x	x
Signal Processing Lab		6	x		x		x	
German modules								
Praktikum Mechatronische Messsysteme	6				x			
Praktikum System-on-Chip	6							x

Field of Specialization: Microelectronics, Photonics and Quantum Technologies

Fundamentals (24 CP)	**CP winter**	**CP summer**	**Microelectronics (Ulusoy, Becker)**	**Radio Frequency Electronics (Ulusoy, Zwick)**	**Quantum Technologies (Kempf)**	**Optics and Photonics (Koos, Lemmer)**
English modules						
Numerical Methods		6	x	x	x	x
Radio-Frequency Electronics	6		x	x	x	x
Integrated Photonics (comming soon)	6		x	x	x	x
Quantum Engineering		6	x	x	x	x
Hardware Synthesis and Optimization		6	x	x	x	x
Focus Area (30 CP)	**CP winter**	**CP summer**				
English modules						
Analog Circuit Design	4		x			
Antennas and Beamforming	4			x	x	
Applied Electromagnetics (starts October 2025)	4			x	x	x
Digital Circuit Design		4	x			
Hardware Modeling and Simulation	4		x			
High-Power Microwave Technology	3			x		
Mixed-Signal IC Design		3	x			
Modern Radio Systems Engineering	6	6		x		
Modern VLSI Technologies		5	x		x	
Nano- and Quantum Electronics		6	x		x	x
Nonlinear Optics		6				x
Optical Transmitters and Receivers	6					x
Optical Waveguides and Fibers	4			x		x
Physics, Technology and Applications of Thin Films	4		x		x	x
Practical Amplifier Design		3	x	x		
Quantum Detectors and Sensors	6				x	x
Radio Frequency Integrated Circuits and Systems		6	x	x		x
Superconductivity for Engineers	5				x	x
German modules						
Mikrowellenmesstechnik (changes to English in April 2026)		4		x	x	
Miniaturisierte passive Mikrowellenschaltungen		4		x	x	
Optoelektronische Messtechnik		3				x
Lab Course (exactly 1)	**CP winter**	**CP summer**				
English modules						
MMIC Design Laboratory	6	6	x	x		
Microwave Engineering Lab	6	6		x		x
Lab Course on Noise Thermometry	6	6			x	

Lab Course on Superconducting Quantum Electronics/ Praktikum Supraleitende Quantenelektronik	6	6			x	
Laboratory Nanotechnology/Praktikum Nanotechnologie	6	6	x		x	
Photonics and Communications Lab		6				x
German modules						
Praktikum System-on-Chip	6		x			

4 General Information

4.1 Study program details

KIT-Department	KIT Department of Electrical Engineering and Information Technology
Academic Degree	Master of Science (M.Sc.)
Examination Regulations Version	2025
Regular terms	4 terms
Maximum terms	8 terms
Credits	120
Language	
Grade calculation	Weighted average by credits
Additional Information	Link to study program www.etit.kit.edu

5 Field of study structure

Mandatory	
Field of Specialization	60 CR
Electives	24 CR

5.1 Field of Specialization

Credits
60

Elective Area - Field of Specialization (Election: at least 60 credits)	
Electrical Power Systems and Electromobility	60 CR
Field of Specialization: Information and Communication Technology	60 CR
Automation, Robotics, and Systems Engineering	60 CR
Microelectronics, Photonics, and Quantum Technologies	60 CR

5.1.1 Electrical Power Systems and Electromobility

Part of: Field of Specialization

Credits
60

Election notes
All modules are listed with English titles, regardless of the course language.

- **Fundamentals**: All modules are given in English.
- **Focus Area** and **Lab Courses**: The primarily mentioned modules (alphabetically ordered) are given in English, the further below mentioned ones in German (alphabetically ordered).

Fundamentals (Election: at least 24 credits)		
M-ETIT-107005	Batteries and Fuel Cells	6 CR
M-ETIT-105394	Electric Power Transmission & Grid Control	6 CR
M-MATH-106972	Numerical Methods with Programming Practice	6 CR
M-ETIT-100531	Optimization of Dynamic Systems	5 CR
M-ETIT-104567	Power Electronics	6 CR
M-ETIT-105611	Superconductivity for Engineers	5 CR
Focus Area (Election: at least 24 credits)		
- English modules -		
M-ETIT-100539	Communication Systems and Protocols	5 CR
M-ETIT-106689	Components of Power Systems	3 CR
M-ETIT-106971	Electric Drives for E-Mobility	4 CR
M-ETIT-105883	Electrocatalysis	5 CR
M-ETIT-101969	Energy Storage and Network Integration	4 CR
M-WIWI-105403	Liberalised Power Markets	3 CR
M-ETIT-105595	Pulsed Power Technology and Applications (Lecture)	3 CR
M-ETIT-105606	Quantum Detectors and Sensors	6 CR
M-WIWI-100500	Renewable Energy-Resources, Technologies and Economics	3 CR
M-ETIT-105615	Seminar on Applied Superconductivity	3 CR
M-ETIT-100524	Solar Energy	6 CR
M-MACH-101924	Solar Thermal Energy Systems	4 CR
M-ETIT-106684	Superconducting Magnet Technology	4 CR
M-ETIT-105521	Superconducting Materials	6 CR
M-ETIT-106683	Superconducting Power Systems	4 CR
M-ETIT-100537	Systems and Software Engineering	5 CR
- German modules -		
M-MACH-100501	Automotive Engineering I	8 CR
M-ETIT-100400	Basics of Converter Control	3 CR
M-ETIT-100377	Battery and Fuel Cells Systems	3 CR
M-ETIT-105915	Control of Power-Electronic Systems	6 CR
M-ETIT-100515	Design of Electrical Machines	5 CR
M-ETIT-100410	Electronics and EMC	3 CR
M-ETIT-100453	Hardware/Software Co-Design	4 CR
M-ETIT-100417	High-Voltage Test Technique	4 CR
M-ETIT-105060	High-Voltage Technology	6 CR
M-ETIT-100399	Industrial Circuitry	3 CR
M-WIWI-100498	Introduction into Energy Economics	5 CR
M-ETIT-105604	Nano- and Quantum Electronics	6 CR
M-ETIT-102200	Packaging and Interconnects for Power Electronic Systems	3 CR
M-ETIT-100513	Photovoltaics	6 CR
M-ETIT-102261	Power Electronics for Photovoltaics and Wind Energy	3 CR
M-ETIT-106067	Power Electronic Systems in Energy Technology	6 CR
M-ETIT-106506	Power System Protection and Automation	3 CR
M-ETIT-100413	Power Systems and Economy	3 CR
M-ETIT-100394	Practical Aspects of Electrical Drives	4 CR
M-ETIT-105916	Real Time Control of Electrical Drives	6 CR
M-ETIT-105629	Seminar Electrocatalysis	3 CR
M-ETIT-100396	Seminar New Components and Systems of Power Electronics	4 CR
M-ETIT-100555	Workshop Finite Element Method in Electromagnetics	3 CR

5.1.2 Field of Specialization: Information and Communication Technology

Part of: Field of Specialization

Credits 60

Election notes
All modules are listed with English titles, regardless of the course language.

- **Fundamentals**: All modules are given in English.
- **Focus Area** and **Lab Courses**: The primarily mentioned modules (alphabetically ordered) are given in English, the further below mentioned ones in German (alphabetically ordered).

Fundamentals (Election: at least 24 credits)		
M-ETIT-106815	Advanced Communications Engineering	6 CR
M-ETIT-100453	Hardware/Software Co-Design	4 CR
M-ETIT-100427	Modern Radio Systems Engineering	4 CR
M-MATH-106972	Numerical Methods with Programming Practice	6 CR
M-ETIT-103270	Optical Networks and Systems	4 CR
M-ETIT-106899	Signal Processing Methods	6 CR
Focus Area (Election: at least 24 credits)		
- work in progress-		

5.1.3 Automation, Robotics, and Systems Engineering

Part of: Field of Specialization

Credits 60

Election notes
All modules are listed with English titles, regardless of the course language.

- **Fundamentals**: All modules are given in English.
- **Focus Area** and **Lab Courses**: The primarily mentioned modules (alphabetically ordered) are given in English, the further below mentioned ones in German (alphabetically ordered).

Fundamentals (Election: at least 24 credits)		
M-ETIT-106953	Cyber-Physical Modeling	6 CR
M-ETIT-106974	Optical Engineering and Machine Vision	6 CR
M-ETIT-100531	Optimization of Dynamic Systems	5 CR
M-ETIT-106899	Signal Processing Methods	6 CR
M-ETIT-100537	Systems and Software Engineering	5 CR
Focus Area (Election: at least 24 credits)		
- work in progress-		

5.1.4 Microelectronics, Photonics, and Quantum Technologies

Part of: Field of Specialization

Credits
60

Election notes
All modules are listed with English titles, regardless of the course language.

- **Fundamentals**: All modules are given in English.
- **Focus Area** and **Lab Courses**: The primarily mentioned modules (alphabetically ordered) are given in English, the further below mentioned ones in German (alphabetically ordered).

Fundamentals (Election: at least 24 credits)		
M-ETIT-106963	Hardware Synthesis and Optimization	6 CR
M-MATH-106972	Numerical Methods with Programming Practice	6 CR
M-ETIT-106954	Quantum Engineering	6 CR
M-ETIT-106955	Radio-Frequency Electronics	6 CR
Focus Area (Election: at least 24 credits)		
- English modules -		
M-ETIT-100466	Analog Circuit Design	4 CR
M-ETIT-106956	Antennas and Beamforming	4 CR
M-ETIT-100473	Digital Circuit Design	4 CR
M-ETIT-100449	Hardware Modeling and Simulation	4 CR
M-ETIT-100521	High-Power Microwave Technology	3 CR
M-ETIT-105893	Mixed-Signal IC Design	3 CR
M-ETIT-100427	Modern Radio Systems Engineering	4 CR
M-ETIT-106921	Modern VLSI Technologies	6 CR
M-ETIT-105604	Nano- and Quantum Electronics	6 CR
M-ETIT-100430	Nonlinear Optics	6 CR
M-ETIT-100436	Optical Transmitters and Receivers	6 CR
M-ETIT-100506	Optical Waveguides and Fibers	4 CR
M-ETIT-105608	Physics, Technology and Applications of Thin Films	4 CR
M-ETIT-105606	Quantum Detectors and Sensors	6 CR
M-ETIT-105123	Radio Frequency Integrated Circuits and Systems	6 CR
M-ETIT-105611	Superconductivity for Engineers	5 CR
- German modules -		
M-ETIT-100424	Microwaves Measurement Techniques	4 CR
M-ETIT-101968	Miniaturized Passive Microwave Circuits	4 CR
M-ETIT-100484	Optoelectronic Measurement Engineering	3 CR
Lab Course (Election: at most 1 item)		
M-ETIT-105464	MMIC Design Laboratory	6 CR
M-ETIT-106973	Microwave Engineering Lab	6 CR
M-ETIT-104485	Photonics and Communications Lab	6 CR
M-ETIT-100478	Laboratory Nanotechnology	6 CR
M-ETIT-100451	System-on-Chip Laboratory	6 CR

5.2 Electives

Credits
24

Elective Modules (Election: at least 24 credits)		
M-ETIT-103802	Adaptive Optics	3 CR
M-ETIT-106815	Advanced Communications Engineering	6 CR
M-ETIT-100507	Current Topics of Solar Energy	3 CR
M-ETIT-100444	Applied Information Theory	6 CR
M-INFO-103294	Wearable Robotic Technologies	4 CR
M-ETIT-102200	Packaging and Interconnects for Power Electronic Systems	3 CR
M-INFO-105338	Authentication and Encryption	4 CR
M-ETIT-100532	Batteries and Fuel Cells	5 CR
M-ETIT-100377	Battery and Fuel Cells Systems	3 CR
M-ETIT-102651	Image Processing	3 CR
M-ETIT-100549	Bioelectric Signals	3 CR
M-MACH-100489	BioMEMS - Microsystems Technologies for Life Sciences and Medicine I	4 CR
M-MACH-100490	BioMEMS - Microsystems Technologies for Life Sciences and Medicine II	4 CR
M-MACH-100491	BioMEMS - Microsystems Technologies for Life Sciences and Medicine III	4 CR
M-ETIT-101834	Business Innovation in Optics and Photonics	4 CR
M-ETIT-105616	Channel Coding: Algebraic Methods for Communications and Storage	3 CR
M-ETIT-105617	Channel Coding: Graph-Based Codes	6 CR
M-ETIT-100539	Communication Systems and Protocols	5 CR
M-ETIT-106689	Components of Power Systems	3 CR
M-INFO-106190	Computational Imaging	5 CR
M-MACH-105296	Computational Intelligence	4 CR
M-CIWVT-104356	Cryogenic Engineering	6 CR
M-ETIT-106039	Cyber Physical Production Systems	4 CR
M-INFO-106505	Data Science	8 CR
M-INFO-105753	Deep Learning for Computer Vision I: Basics	3 CR
M-INFO-105755	Deep Learning for Computer Vision II: Advanced Topics	3 CR
M-INFO-104460	Deep Learning and Neural Networks	6 CR
M-ETIT-100466	Analog Circuit Design	4 CR
M-ETIT-100473	Digital Circuit Design	4 CR
M-ETIT-100541	Detectores for Applications in Space and Astronomy	3 CR
M-ETIT-105618	The Energy Transition of the Electrical Transmission Grid	3 CR
M-ETIT-102266	Digital Hardware Design Laboratory	6 CR
M-ETIT-106690	Digital Real Time Simulations for Energy Technologies	3 CR
M-ETIT-103450	Digital Signal Processing in Optical Communications – with Practical Exercises	6 CR
M-ETIT-106040	Digital Twin Engineering	4 CR
M-ETIT-105415	Digital Beam-Forming for Imaging Radar	4 CR
M-ETIT-101847	Dosimetry of Ionising Radiation	3 CR
M-ETIT-105916	Real Time Control of Electrical Drives	6 CR
M-INFO-100736	Introduction to Video Analysis	3 CR
M-WIWI-100498	Introduction into Energy Economics	5 CR
M-ETIT-106597	Single-Crystal Growth – Crystal Growth Methods and Applications of Crystals for Electronic and Optical Components	3 CR
M-ETIT-105394	Electric Power Transmission & Grid Control	6 CR
M-ETIT-101917	Electric Power Generation and Power Grid	3 CR
M-ETIT-105883	Electrocatalysis	5 CR
M-ETIT-100386	Electromagnetics and Numerical Calculation of Fields	4 CR
M-ETIT-100572	Power Network	5 CR
M-ETIT-100511	Electronic Circuits for Light Sources and Laser	3 CR
M-ETIT-100410	Electronics and EMC	3 CR
M-ETIT-100419	Lab Course Electrical Power Engineering	6 CR
M-CIWVT-104288	Biomass Based Energy Carriers	6 CR

M-ETIT-100413	Power Systems and Economy	3 CR
M-ETIT-101969	Energy Storage and Network Integration	4 CR
M-ETIT-100515	Design of Electrical Machines	5 CR
M-INFO-100831	Design and Architectures of Embedded Systems (ES2)	3 CR
M-ETIT-105701	Microwave Module Design	3 CR
M-ETIT-101919	Fabrication and Characterisation of Optoelectronic Devices	3 CR
M-MACH-105288	Handling Characteristics of Motor Vehicles I	4 CR
M-MACH-102693	Automotive Vision	6 CR
M-ETIT-100566	Field Propagation and Coherence	4 CR
M-INFO-106299	Advanced Artificial Intelligence	6 CR
M-ETIT-103241	Radio Receivers	3 CR
M-INFO-100725	Human Brain and Central Nervous System: Anatomy, Information Transfer, Signal Processing, Neurophysiology and Therapy	3 CR
M-BGU-106347	Geodetic Space Techniques for Engineers	4 CR
M-MACH-100501	Automotive Engineering I	8 CR
M-MACH-100502	Automotive Engineering II	4 CR
M-MACH-102691	Introduction to Microsystem Technology I	4 CR
M-MACH-105289	Principles of Whole Vehicle Engineering I	2 CR
M-MACH-105290	Principles of Whole Vehicle Engineering II	2 CR
M-ETIT-100483	Fundamentals on Plasma Technology	3 CR
M-ETIT-100449	Hardware Modeling and Simulation	4 CR
M-ETIT-100453	Hardware/Software Co-Design	4 CR
M-ETIT-106963	Hardware Synthesis and Optimization	6 CR
M-ETIT-100521	High-Power Microwave Technology	3 CR
M-ETIT-100417	High-Voltage Test Technique	4 CR
M-ETIT-105060	High-Voltage Technology	6 CR
M-ETIT-103264	Information Fusion	4 CR
M-ETIT-100367	Information Technology in Industrial Automation Systems	3 CR
M-ETIT-100457	Integrated Intelligent Sensors	3 CR
M-ETIT-100474	Integrated Systems and Circuits	4 CR
M-ETIT-103076	Interfaculty Team Project	6 CR
M-ETIT-105461	Introduction to Automotive and Industrial Lidar Technology	3 CR
M-ETIT-106789	IT/OT-Security Seminar	4 CR
M-CIWVT-104354	Refrigeration B - Foundations of Industrial Gas Processing	6 CR
M-INFO-105631	Cryptographic Protocols	5 CR
M-ETIT-106263	Lab Course on Noise Thermometry	6 CR
M-ETIT-106464	Lab Course Printed Flexible Electronics	6 CR
M-ETIT-105467	Control Theory Laboratory	6 CR
M-ETIT-100518	Laboratory Circuit Design *First usage possible until Sep 30, 2025.*	6 CR
M-ETIT-105402	Laboratory Modern Software Tools in Power Engineering	6 CR
M-ETIT-100434	Laser Metrology	3 CR
M-ETIT-100435	Laser Physics	4 CR
M-ETIT-102261	Power Electronics for Photovoltaics and Wind Energy	3 CR
M-ETIT-106067	Power Electronic Systems in Energy Technology	6 CR
M-WIWI-105403	Liberalised Power Markets	3 CR
M-ETIT-100485	Lighting Engineering	4 CR
M-ETIT-100512	Light and Display Engineering	4 CR
M-ETIT-100577	Lighting Design - Theory and Applications	3 CR
M-INFO-100840	Localization of Mobile Agents	6 CR
M-INFO-100807	Low Power Design	3 CR
M-ETIT-104988	Machine Learning and Optimization in Communications	4 CR
M-WIWI-106604	Machine Learning and Optimization in Energy Systems	4 CR

M-MACH-101923	Machine Vision	8 CR
M-WIWI-105003	Machine Learning 1	5 CR
M-WIWI-105006	Machine Learning 2	5 CR
M-ETIT-105982	Measurement Technology	5 CR
M-MACH-102699	Laboratory Mechatronics	4 CR
M-ETIT-106672	Medical Image Processing for Guidance and Navigation	9 CR
M-ETIT-106778	Medical Imaging Technology *First usage possible until Mar 31, 2026.*	6 CR
M-ETIT-106670	Medical Imaging Technology II *First usage possible until Sep 30, 2025.*	3 CR
M-ETIT-106679	Medical Measurement Technology *First usage possible until Sep 30, 2025.*	6 CR
M-MACH-102714	Microenergy Technologies	4 CR
M-MACH-100487	Microactuators	4 CR
M-ETIT-100454	Microsystem Technology	3 CR
M-ETIT-100424	Microwaves Measurement Techniques	4 CR
M-ETIT-100535	Microwave Engineering	5 CR
M-ETIT-101968	Miniaturized Passive Microwave Circuits	4 CR
M-ETIT-105893	Mixed-Signal IC Design	3 CR
M-ETIT-105464	MMIC Design Laboratory	6 CR
M-ETIT-105971	Mobile Communications	4 CR
M-ETIT-106244	Mobile Communications II	3 CR
M-ETIT-106456	Mobile Communications Workshop	4 CR
M-ETIT-100508	Modelling and Simulation of Electrochemical Systems	3 CR
M-MACH-102592	Modeling and Simulation	7 CR
M-ETIT-100427	Modern Radio Systems Engineering	4 CR
M-ETIT-106921	Modern VLSI Technologies	6 CR
M-INFO-100825	Pattern Recognition	6 CR
M-ETIT-105274	Communications Engineering II *First usage possible until Sep 30, 2025.*	4 CR
M-ETIT-105604	Nano- and Quantum Electronics	6 CR
M-ETIT-105881	Navigation and Localization Techniques	3 CR
M-ETIT-100371	Nonlinear Control Systems	3 CR
M-CIWVT-105890	NMR Methods for Product and Process Analysis	4 CR
M-ETIT-100430	Nonlinear Optics	6 CR
M-MATH-105831	Numerical Methods	5 CR
M-ETIT-102311	Numerical Methods for Partial Differential Equations	4 CR
M-ETIT-100464	Optical Design Lab	6 CR
M-ETIT-100456	Optical Engineering	4 CR
M-ETIT-103270	Optical Networks and Systems	4 CR
M-ETIT-103252	Optical Systems in Medicine and Life Science	3 CR
M-ETIT-100436	Optical Transmitters and Receivers	6 CR
M-ETIT-100506	Optical Waveguides and Fibers	4 CR
M-ETIT-102310	Optimal Control and Estimation	3 CR
M-INFO-100830	Optimization and Synthesis of Embedded Systems (ES1)	3 CR
M-ETIT-100531	Optimization of Dynamic Systems	5 CR
M-ETIT-100486	Optical Technologies for Automotive Applications	3 CR
M-ETIT-100509	Optoelectronic Components	4 CR
M-ETIT-100480	Optoelectronics *First usage possible until Sep 30, 2025.*	4 CR
M-ETIT-100484	Optoelectronic Measurement Engineering	3 CR
M-ETIT-100519	Photometry and Radiometry	3 CR
M-ETIT-105914	Photonic Integrated Circuit Design and Applications	6 CR
M-ETIT-104485	Photonics and Communications Lab	6 CR

M-ETIT-100513	Photovoltaics	6 CR
M-ETIT-105468	Physical and Data-Based Modelling	6 CR
M-CIWVT-103068	Physical Foundations of Cryogenics	6 CR
M-ETIT-105608	Physics, Technology and Applications of Thin Films	4 CR
M-ETIT-105874	Physiology and Anatomy for Biomedical Engineering *First usage possible until Sep 30, 2025.*	6 CR
M-ETIT-100481	Plasma Sources	4 CR
M-ETIT-100475	Plastic Electronics / Polymerelectronics	3 CR
M-ETIT-104567	Power Electronics	6 CR
M-ETIT-106780	Practical Tools for Control Engineers	4 CR
M-ETIT-100381	Batteries and Fuel Cells Laboratory	6 CR
M-ETIT-100389	Laboratory Biomedical Engineering	6 CR
M-ETIT-100401	Lab Course Electrical Drives and Power Electronics	6 CR
M-ETIT-102264	Digital Hardware Design Laboratory	6 CR
M-ETIT-100415	Laboratory Information Systems in Power Engineering	6 CR
M-ETIT-102356	Laboratory Lighting Technology	6 CR
M-ETIT-103448	Laboratory Mechatronic Measurement Systems	6 CR
M-ETIT-105300	Microwave Engineering Lab	6 CR
M-ETIT-100442	Communications Engineering Laboratory	6 CR
M-ETIT-100468	Lab Course on Nanoelectronics	6 CR
M-ETIT-100478	Laboratory Nanotechnology	6 CR
M-ETIT-100477	Laboratory Optoelectronics	6 CR
M-ETIT-100470	Laboratory FPGA Based Circuit Design	6 CR
M-INFO-105955	Practical Course: Smart Energy System	6 CR
M-ETIT-100460	Laboratory in Software Engineering	6 CR
M-ETIT-102350	Laboratory Solar Energy	6 CR
M-ETIT-105605	Lab Course on Superconducting Quantum Electronics	6 CR
M-ETIT-100451	System-on-Chip Laboratory	6 CR
M-ETIT-106673	Practical Machine Learning	5 CR
M-ETIT-100394	Practical Aspects of Electrical Drives	4 CR
M-ETIT-104475	Project Management in the Development of Products for Safety-Critical Applications	4 CR
M-WIWI-106491	Project Lab Applied Machine Learning	5 CR
M-ETIT-105594	Process Analysis: Modeling, Data Mining, Machine Learning	3 CR
M-ETIT-105595	Pulsed Power Technology and Applications (Lecture)	3 CR
M-ETIT-105596	Pulsed Power Technology and Applications (Tutorial)	5 CR
M-ETIT-105606	Quantum Detectors and Sensors	6 CR
M-ETIT-105889	Quantum Machine Learning	3 CR
M-ETIT-105273	Source Coding Techniques	3 CR
M-ETIT-100420	Radar Systems Engineering	6 CR
M-ETIT-105124	Radio-Frequency Electronics	5 CR
M-ETIT-105123	Radio Frequency Integrated Circuits and Systems	6 CR
M-ETIT-105915	Control of Power-Electronic Systems	6 CR
M-ETIT-100374	Control of Linear Multivariable Systems	6 CR
M-WIWI-100500	Renewable Energy-Resources, Technologies and Economics	3 CR
M-INFO-102522	Robotics - Practical Course	6 CR
M-INFO-100893	Robotics I - Introduction to Robotics *First usage possible until Sep 30, 2025.*	6 CR
M-INFO-102756	Robotics II - Humanoid Robotics	3 CR
M-INFO-104897	Robotics III - Sensors and Perception in Robotics	3 CR
M-ETIT-105272	Satellite Communications	3 CR
M-ETIT-100399	Industrial Circuitry	3 CR
M-ETIT-106506	Power System Protection and Automation	3 CR
M-ETIT-106674	Seminar Advanced Concepts for Flexible and Soft Optoelectronic Devices and Sensors	3 CR

M-ETIT-100441	Seminar Selected Topics in Communication	4 CR
M-INFO-102374	Seminar Accessibility - Assistive Technologies for Visually Impaired Persons	3 CR
M-ETIT-105321	Seminar Battery II	3 CR
M-ETIT-105322	Seminar Fuel Cell II	3 CR
M-ETIT-100455	Seminar Embedded Systems	4 CR
M-ETIT-105629	Seminar Electrocatalysis	3 CR
M-ETIT-100396	Seminar New Components and Systems of Power Electronics	4 CR
M-ETIT-103447	Seminar Novel Concepts for Solar Energy Harvesting	3 CR
M-ETIT-105615	Seminar on Applied Superconductivity	3 CR
M-ETIT-100428	Seminar Radar and Communication Systems	4 CR
M-ETIT-100380	Seminar Sensors	3 CR
M-ETIT-100378	Sensors	3 CR
M-INFO-104877	Safe Human-Robot-Collaboration	3 CR
M-ETIT-106633	Signal Processing Lab	6 CR
M-ETIT-106899	Signal Processing Methods	6 CR
M-ETIT-106675	Signal Processing with Nonlinear Fourier Transforms and Koopman Operators	6 CR
M-ETIT-100443	Signal Processing in Communications	4 CR
M-ETIT-101971	Single-Photon Detectors	4 CR
M-ETIT-100450	Software Engineering	3 CR
M-ETIT-100524	Solar Energy	6 CR
M-ETIT-103042	Spaceborne Radar Remote Sensing	6 CR
M-ETIT-100545	Space-Born Microwave Radiometry - Advanced Methods and Applications	3 CR
M-MACH-105348	Control Technology	4 CR
M-INFO-100829	Stochastic Information Processing	6 CR
M-ETIT-100400	Basics of Converter Control	3 CR
M-ETIT-105073	Student Innovation Lab	15 CR
M-ETIT-106684	Superconducting Magnet Technology	4 CR
M-ETIT-105521	Superconducting Materials	6 CR
M-ETIT-105609	Superconducting Nanowire Detectors	4 CR
M-ETIT-106683	Superconducting Power Systems	4 CR
M-ETIT-105611	Superconductivity for Engineers	5 CR
M-ETIT-106026	System Integration and Communication Structures in Industry 4.0 and IoT	3 CR
M-ETIT-100537	Systems and Software Engineering	5 CR
M-ETIT-100462	Systems Engineering for Automotive Electronics	4 CR
M-ETIT-105465	Team Project: Sensors and Electronics	3 CR
M-ETIT-101835	Technical Acoustic	3 CR
M-ETIT-100538	Technical Optics	5 CR
M-INFO-100801	Telematics	6 CR
M-ETIT-100546	Test of Embedded Systems in Industrial Contexts	4 CR
M-INFO-105584	Theoretical Foundations of Cryptography	6 CR
M-MACH-102388	Thermal Solar Energy	4 CR
M-ETIT-100560	Ultrasound Imaging	3 CR
M-INFO-105783	Universal Composability in Cryptography	3 CR
M-CIWVT-104478	Vacuum Technology	6 CR
M-ETIT-104493	Verified Numerical Methods	4 CR
M-ETIT-100361	Distributed Discrete Event Systems	4 CR
M-ETIT-100497	Visual Perception in the Automobile	3 CR
M-CIWVT-106680	Water – Energy – Environment Nexus in a Circular Economy: Research Proposal Preparation	5 CR
M-MACH-101286	Machine Tools and Industrial Handling	9 CR
M-MACH-105369	Scientific Computing for Engineers	4 CR
M-ETIT-100555	Workshop Finite Element Method in Electromagnetics	3 CR

6 Modules

M 6.1 Module: Adaptive Optics [M-ETIT-103802]

Responsible: Dr. Szymon Gladysz
Prof. Dr. Ulrich Lemmer

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	English	4	3

Mandatory			
T-ETIT-107644	Adaptive Optics	3 CR	Gladysz, Lemmer

Competence Certificate
Type of Examination: Oral examination

Duration of Examination: approx. 30 Minutes

Modality of Exam: The oral exam will be scheduled during the semester break.

Prerequisites
None.

Competence Goal
The students will:

- get familiar with Fourier description of imaging through aberrated optical systems and random media,
- understand the description of aberrations through Zernike modes,
- learn how to analytically compute the effects of turbulence on various optical observables such as image/beam motion, temporal power spectra, Zernike modes, scintillation, etc.,
- understand the effect of noise on various quantities and metrics pertinent to the design of adaptive optical systems,
- understand the advantages and disadvantages of various schemes for wavefront sensing and correction,
- learn how to simulate and design simple adaptive optics systems.

Content
Adaptive optics is a technology of correcting the effect of atmospheric turbulence on images of space objects and on laser beams propagating through random and highly aberrated media such as turbulence, tissue, and the inside of the human eye, to name just a few applications. The course will familiarize the students with theoretical basics of light propagation through random media, principles of wavefront sensing and reconstruction, as well as wavefront correction with deformable mirrors. The students will also receive solid introduction to statistical optics, the Kolmogorov theory of turbulence, practical aspects of turbulence simulation and modelling of adaptive optics.

1. Theory of turbulence (covariances, structure functions, power spectra, inertial range, dimensional argument of Kolmogorov)
2. Fourier optics (point-spread function, modulation transfer function)
3. Statistical optics (characteristic function, probability density function)
4. Sources and description of aberrations (Zernike polynomials, orthogonality, Marechal criterion)
5. Adaptive optics systems (open- and closed-loop systems, error budgets, tip-tilt correction)
6. Wavefront sensing (Shack-Hartmann wavefront sensor, wavefront reconstruction, wavefront-sensorless AO)
7. Wavefront correction (tip-tilt mirrors, deformable mirrors, piezoelectric effect, microelectromechanical systems, electrostatic actuation)
8. Simulation of adaptive optical systems (analytic vs. end-to-end modelling)
9. Propagation of laser beams through atmospheric turbulence (Gaussian beams, Rytov theory, scintillation index, beam wander)
10. Modelling of free-space optical communication systems (aperture averaging, mean signal-to-noise ratio, false-alarm rate and fade probability, bit error-rate)

Module grade calculation
The module grade is the grade of the oral exam.

Workload
total 90 h, hereof 30 h contact hours and 60 h homework and self-studies

Recommendation
Basic knowledge of statistics.

Literature
Robert K. Tyson, Principles of Adaptive Optics, CRC Press

Michael C. Roggemann, Byron M. Welsh, Imaging through Turbulence, CRC Press

M 6.2 Module: Advanced Artificial Intelligence [M-INFO-106299]

Responsible: Prof. Dr. Jan Niehues
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-INFO-112768	Advanced Artificial Intelligence	6 CR	Niehues

Competence Certificate
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
- The students know the relevant elements of a technical cognitive system.
- The students understand the algorithms and methods of AI to model cognitive systems.
- The students are able to understand the different sub-components to develop and analyze a system .
- The students can transfer this knowledge to new applications, as well as analyze and compare different methods.

Content
Due to the successes in research, AI systems are increasingly integrated into our everyday lives. These are, for example, systems that can understand and generate language or analyze images and videos. In addition, AI systems are essential in robotics in order to be able to develop the next generation of intelligent robots .

Based on the knowledge of the lecture “Introduction to AI”, the students learn to understand, develop and evaluate these systems.
In order to bring this knowledge closer to the students, the lecture is divided into 4 parts. First, the lecture investigates method of perception using different modalities. The second part deals with advanced methods of learning that go beyond supervised learning. Then methods are discussed that are required for the representation of knowledge in AI systems. Finally, methods that enable AI systems to generate content are presented.

Workload
Lecture with 3 SWS + 1 SWS exercise , 6 CP.
6 LP corresponds to approx. 180 hours, of which
approx. 45 hours lecture attendance
approx. 15 hours exercise visit
approx. 90 hours post-processing and processing of the exercise sheets
approx. 30 hours exam preparation

M 6.3 Module: Advanced Communications Engineering [M-ETIT-106815]

Responsible: Dr.-Ing. Holger Jäkel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Field of Specialization: Information and Communication Technology
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-113676	Advanced Communications Engineering	6 CR	Jäkel

Competence Certificate
The assessment takes place in the form of a written examination lasting 120 min,

Prerequisites
none

Competence Goal
The students are able to analyze and assess properties of communication systems and consider aspects of implementation. They can use mathematical methods in the context of communication systems for understanding involved derivations in the research literature; deriving and autonomously elaborating theoretical results, and checking their viability by simulations.

Content
The module is introducing and deriving results covering, but not being limited to, properties of linear modulation, channel description and diversity schemes, and processing of receiver signals, all based on detailed theoretical concepts. Topics already covered in previous modules are deduced thoroughly and mathematical derivations and reasoning are provided.

Module grade calculation
The module grade is the grade of the written exam.

Annotation
Starting winter term 25/26

Workload

1.
    1. Attendance to the lecture: 20 * 1,5 h = 30 h
    2. Preparation and review: 20 * 3 h = 60 h
    3. Attendance to the tutorial: 6 * 1,5 h = 9 h
    4. Preparation and review: 6 * 3,5 h = 21 h
    5. Preparation for the exam: 60 h

    In total: 180 h = 6 LP

Recommendation
Basics knowledge of communication systems, as, e.g., provided in KIT’s Bachelor courses “Grundlagen der Datenübertragung” and “Nachrichtensysteme”, is supposed. Furthermore, working knowledge in the areas of system theory and probability theory is assumed.

Learning type
Lecture: 3 SWS, Exercise: 1 SWS

6.4 Module: Analog Circuit Design [M-ETIT-100466]

Responsible: Prof. Dr. Ivan Peric
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100973	Analog Circuit Design	4 CR	Peric

Annotation
Will be changed to English in winter term 25/26.

6.5 Module: Antennas and Beamforming [M-ETIT-106956]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-113920	Antennas and Beamforming	4 CR	Zwick

Competence Certificate
The examination takes place in form of a written examination lasting 120 minutes.

Prerequisites
none

Competence Goal
After successfully participating in this course, students have in-depth knowledge of antennas, antenna systems and beamforming methods. This includes functionality, calculation methods as well as aspects of practical implementation. They are able to understand how typical electromagnetic radiators work and to develop and dimension them with specified properties. Students understand the principle and function of beamforming and the differences between digital, analog and hybrid beamforming. They know the theory, procedures and algorithms for beamforming. They can understand how beamforming is used for radio communication and radar.

Content
The lecture begins with a brief review of the basic knowledge of antennas and antenna arrays from the Bachelor's course. This is followed by a detailed discussion of all major antenna types (functionality, specifics). Furthermore, antenna measurement methods are presented. In the second part, the basic knowledge of noise, radio transmission and radar ambiguities is briefly refreshed, followed by a detailed presentation of the various beamforming algorithms, each with reference to radio communication and radar systems. Aspects such as digital and hybrid beamforming, as well as MIMO and equivalent virtual antenna configuration are explained.

The lecture will be accompanied by exercises. These are discussed in a room exercise and the corresponding solutions are presented in detail.

Module grade calculation
The module grade is the grade of the written exam.

Workload
The workload includes:

- Attendance study time lecture: 30 h
- Attendance study time exercise: 15 h
- Self-study time including exam preparation: 75 h

A total of 120 h

Recommendation
Knowledge of the basics of radio frequency technology and some basic knowledge on communication and radar systems is recommended.

6.6 Module: Applied Information Theory [M-ETIT-100444]

Responsible: Dr.-Ing. Holger Jäkel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100748	Applied Information Theory	6 CR	Jäkel

Competence Certificate
The success control takes place in the form of an oral examination lasting 25 minutes. Before the examination, there is a preparation phase of 15 minutes in which preparatory tasks are solved.

Prerequisites
none

M 6.7 Module: Authentication and Encryption [M-INFO-105338]

Responsible: Prof. Dr. Jörn Müller-Quade
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-INFO-110824	Authentication and Encryption	4 CR	Müller-Quade

M 6.8 Module: Automotive Engineering I [M-MACH-100501]

Responsible: Prof. Dr.-Ing. Marcus Geimer
Organisation: KIT Department of Mechanical Engineering

Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-MACH-100092	Automotive Engineering I	8 CR	Gießler

Competence Certificate
written exam; duration approximately 2 hours

Prerequisites
Only one out of the two moduls "M-MACH-100501 - Grundlagen der Fahrzeugtechnik I" and "M-MACH-102686 - Automotive Engineering I" is allowed.

Competence Goal
The students know the movements and the forces at the vehicle and are familiar with active and passive security. They have proper knowledge about operation of engines and alternative drives, the necessary transmission between engine and drive wheels and the power distribution, so that they can apply their knowledge effectively in actual practise. They have an overview of the components necessary for the drive and have the basic knowledge, to analyze, to judge and to develop the complex system "vehicle".

Content
The module provides an overview of:

1. History and future of the automobile

2. Driving mechanics: driving resistances and driving performances, mechanics of the longitudinal and transverse forces, passive safety

3. Engines: combustion engine, alternative drives (e.g. electric motor, fuel cell)

4. Transmission: clutches (e.g. friction clutch, visco clutch), transmission (e.g. mechanical transmission, hydraulic fluid transmission)

5. Power transmission and distribution: drive shafts, cardon joints, differentials

Workload
1. regular attendance lecture: 15 * 2 * 2 h = 60 h

2. pre and post processing lecture: 15 * 2 * 3 h = 90 h

3. examination preparation and presence in examination: 90 h

In total: 240 h = 8 LP

Literature
1. Mitschke, M./ Wallentowitz, H.: Dynamik der Kraftfahrzeuge, Springer-Verlag, Berlin, 2004

2. Braes, H.-H.; Seiffert, U.: Handbuch Kraftfahrzeugtechnik, Vieweg&Sohn Verlag, 2005

3. Gnadler, R.: Script to the lecture 'Automotive Engineering I'

6.9 Module: Automotive Engineering II [M-MACH-100502]

Responsible: Prof. Dr.-Ing. Marcus Geimer
Dr.-Ing. Martin Gießler

Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-MACH-102117	Automotive Engineering II	4 CR	Gießler

Competence Certificate
Written exam; duration approximately 1,5 h

Prerequisites
none

Competence Goal
The students have an overview of the modules, which are necessary for the road holding of a motor vehicle and the power transmission between vehicle bodywork and roadway. They have knowledge of different wheel suspensions, the tyres, the steering elements and the brakes. They know different execution forms, the function and the influence on the driving or brake behavior. They can apply their knowledge effectively in actual practise.They are able to develop the appropriate components correctly. They are ready to analyze, to judge and to optimize the complex relationship of the different components under consideration of boundary conditions.

Content
The module provides an overview of:

1. Chassis: Wheel suspensions (rear axles, front axles, kinematics of axles), tyres, springs, damping devices
2. Steering elements: Manual steering, servo steering, steer by wire
3. Brakes: Disc brake, drum brake, comparison of the designs

Workload
1. regular attendance lecture: 15 * 2 h = 30 h

2. pre and postprocessing lecture: 15 * 3 h = 45 h

3. examination preparation and presence in examnation: 45 h

In total: 120 h = 4 LP

Literature
1. Heißing, B./Ersoy, M.: Fahrwerkhandbuch: Grundlagen, Fahrdynamik, Komponenten, Systeme, Mechatronik, Perspektiven, Vieweg-Verlag, Wiesbaden, 2011

2. Breuer, B./Bill, K.-H.: Bremsenhandbuch: Grundlagen - Komponenten - Systeme - Fahrdynamik, Vieweg-Verlag, Wiesbaden, 2012

3. Gnadler, R.: Script to the lecture 'Automotive Engineering II'

M 6.10 Module: Automotive Vision [M-MACH-102693]

Responsible: Dr. Martin Lauer
Prof. Dr.-Ing. Christoph Stiller

Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	2

Mandatory			
T-MACH-105218	Automotive Vision	6 CR	Lauer, Stiller

Competence Certificate
Type of Examination: written exam

Duration of Examination: 60 minutes

Prerequisites
none

Competence Goal
After having participated in th lecture the participants have gained knowledge on modern techniques of signal processing and artificial intelligence which can be used to evaluate video sequences, to relate the image content to a spatial context and to interpret the content semantically. This comprises, binocular reconstruction, recognition of movements in video sequences, state space modeling and Bayesian filters, and the recognition of road surfaces and object behavior. The participants have learned to analyze the algorithms mathematically, to implement them in software, and to apply them to tasks in autonomous driving and mobile robots. The participants are able to analyze problems in the areas mentioned before and to develop appropriate solutions.

Content
Machine perception and interpretation of the environment forms the basis for the generation of intelligent behavior. Especially visual perception opens the door to novel automotive applications. Driver assistance systems already improve safety, comfort and efficiency in vehicles. Yet, several decades of research will be required to achieve an automated behavior with a performance equivalent to a human operator. The lecture addresses students in mechanical engineering and related subjects who intend to get an interdisciplinary knowledge in a state-of-the-art technical domain. Machine vision and advanced information processing techniques are presented to provide a broad overview on seeing vehicles. Application examples from cutting-edge and future driver assistance systems illustrate the discussed subjects. The lecture consists out of 2 hours/week of lecture and 1 hour/week of computer exercises. In the computer exercises methods introduced in the lecture will be implemented in MATLAB and tested experimentally.

Workload
180 hours

composed out of

hours of lecture: 15*3 h = 45 h

preparation time prior to and after lecture: 15*5 h = 75 h

exam preparation and exam: 60 h

Learning type
Lecture

Literature
TBA

M 6.11 Module: Basics of Converter Control [M-ETIT-100400]

Responsible: Dr.-Ing. Andreas Liske
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100717	Basics of Converter Control	3 CR	Liske

Prerequisites
none

6.12 Module: Batteries and Fuel Cells [M-ETIT-100532]

Responsible: Prof. Dr.-Ing. Ulrike Krewer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	German	4	2

Mandatory			
T-ETIT-100983	Batteries and Fuel Cells	5 CR	Krewer

Competence Certificate
Success is assessed in the form of a written examination lasting 120 minutes

Prerequisites
none

Competence Goal
Students gain an understanding of the structure and mode of operation of batteries and fuel cells. They acquire in-depth knowledge of materials, construction concepts, measurement methods, measurement data analysis and modeling, which gives them a practical insight into current areas of application and research topics of electrochemical energy storage and conversion (fuel cells). They are able to communicate with specialists from related disciplines in the field of batteries and fuel cells and can actively contribute to the opinion-forming process in society with regard to energy technology issues.

Content
Fuel cells and batteries used in innovative energy and environmental technology applications will be covered. The course is divided into three sections. Firstly, the basics of thermodynamics, electrochemistry and the lossy mass transport processes involved in energy conversion are discussed. The second section deals with the structure and functional principle of fuel cells and presents the most important approaches to electrical characterization and modelling. Applications in mobile and stationary systems in transportation and energy technology are discussed. The third section deals with electrochemical energy storage systems, with a focus on high-performance batteries for electric traction. Developments to increase energy density and power density are presented here, as well as the electrical characterization and modelling of batteries.

Module grade calculation
The module grade is the grade of the written examination.

Annotation
Will be changed to 6 CR in winter term 25/26.

Workload
1. lecture attendance time: 15 * 2 h = 30 h
2. Preparation and follow-up time for lecture: 15 * 6 h = 90 h
3. Exercise attendance time: 5 * 2 h = 10 h
4. Preparation and follow-up time for exercise: 5 * 4 h = 20 h
5. Exam preparation and attendance: included in preparation and follow-up time.

Total: 150 h = 5 CP

6.13 Module: Batteries and Fuel Cells [M-ETIT-107005]

Responsible: Prof. Dr.-Ing. Ulrike Krewer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Fundamentals)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-113986	Batteries and Fuel Cells	6 CR	Krewer

Competence Certificate
Success is assessed in the form of a written examination lasting 120 minutes

Prerequisites
none

Competence Goal
Students gain an understanding of the structure and mode of operation of batteries and fuel cells. They acquire in-depth knowledge of materials, construction concepts, measurement methods, measurement data analysis and modeling, which gives them a practical insight into current areas of application and research topics of electrochemical energy storage and conversion (fuel cells). They are able to communicate with specialists from related disciplines in the field of batteries and fuel cells and can actively contribute to the opinion-forming process in society with regard to energy technology issues.

Content
Fuel cells and batteries used in innovative energy and environmental technology applications will be covered. The course is divided into three sections. Firstly, the basics of thermodynamics, electrochemistry and the lossy mass transport processes involved in energy conversion are discussed. The second section deals with the structure and functional principle of fuel cells and presents the most important approaches to electrical characterization and modelling. Applications in mobile and stationary systems in transportation and energy technology are discussed. The third section deals with electrochemical energy storage systems, with a focus on high-performance batteries for electric traction. Developments to increase energy density and power density are presented here, as well as the electrical characterization and modelling of batteries.

Module grade calculation
The module grade is the grade of the written examination.

Workload
1. lecture attendance time: 15 * 2 h = 30 h
2. Preparation and follow-up time for lecture: 15 * 4 h = 60 h
3. Exercise attendance time: 15 * 2 h = 30 h
4. Preparation and follow-up time for exercise: 15 * 4 h = 60 h
5. Exam preparation and attendance: included in preparation and follow-up time.

Total: 180 h = 6 CP

6.14 Module: Batteries and Fuel Cells Laboratory [M-ETIT-100381]

Responsible: Dr.-Ing. Andre Weber
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100708	Batteries and Fuel Cells Laboratory	6 CR	Weber

Prerequisites
none

M 6.15 Module: Battery and Fuel Cells Systems [M-ETIT-100377]

Responsible: Dr.-Ing. Andre Weber
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100704	Battery and Fuel Cells Systems	3 CR	Weber

M 6.16 Module: Bioelectric Signals [M-ETIT-100549]

Responsible: Dr.-Ing. Axel Loewe
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-101956	Bioelectric Signals	3 CR	Loewe

Competence Certificate
The success control is carried out as part of a written test of 90 minutes.

Prerequisites
none

Module grade calculation
The module grade is the grade of the written exam. The submission of the workshop tasks is a prerequisite for taking the written exam. If there is a very good oral discussion of the workshop tasks, 5 points can be earned for each of the two workshop parts (from 100). The bonus points are only taken into account if the exam is passed. Bonus points do not expire and are retained for examinations that may be taken at a later date. The final assessment of the bonus performance is carried out by the examiner and is documented.

Workload
Attendance time lecture: 8 * 1.5h = 12h

Preparation / follow-up lecture: 8 * 1h = 8h

Workshop tasks: 20h + 15h = 35h

Exam preparation and attendance in the same: 35h

Total: 90h

Recommendation
Knowledge of the basics of signal processing and physiology is helpful.

Fundamentals of linear electrical networks, Fourier transformation as well as differential equations and systems of linear equations and numerical solution methods

6.17 Module: Biomass Based Energy Carriers [M-CIWVT-104288]

Responsible: Dr.-Ing. Siegfried Bajohr
Organisation: KIT Department of Chemical and Process Engineering
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-CIWVT-108828	Energy from Biomass	6 CR	Bajohr

Competence Certificate
The examination is an oral examination with a duration of about 20 minutes (section 4 subsection 2 number 2 SPO).

Prerequisites
None

Competence Goal
The course mediates fundamentals and process engineering aspects of biomass conversion and conditioning processes. The students learn to understand and to evaluate processes for biomass utilization by balancing mass and energy streams. Taking into account regional and global feedstock potentials the students are enabled to choose the most efficient conversion technologies.

Content
Fundamentals on biomass and its production pathways to energy carriers like substitute natural gas (SNG), bio diesel or other fuels.

Production, properties, and characterization of biomass.

Potential and sustainability; energy demand and supply, potentials today and in the future, CO2 emissions and reduction potential.

Utilization and conversion of biogenic oils and fats.

Biochemical conversion to liquid products like alcohols; fermentation to biogas and its upgrading.

Thermochemical conversion of biomass via pyrolysis and gasification; examples for synthesis processes (FT-, CH4-, CH3OH-, DME-synthesis).

Module grade calculation
The grade of the oral examination is the module grade.

Workload
- Attendance time (Lecture): 45 h
- Homework: 75 h
- Exam Preparation: 60 h

Literature
- Kaltschmitt, M.; Hartmann (Ed.): Energie aus Biomasse, 2. Aufl., Springer Verlag 2009.
- Graf, F.; Bajohr, S. (Hrsg.): Biogas: Erzeugung – Aufbereitung – Einspeisung, 2. Aufl., Oldenbourg Industrieverlag 2013.

M 6.18 Module: BioMEMS - Microsystems Technologies for Life Sciences and Medicine I [M-MACH-100489]

Responsible: Prof. Dr. Andreas Guber
Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-MACH-100966	BioMEMS - Microsystems Technologies for Life-Sciences and Medicine I	4 CR	Guber

Competence Certificate
Written exam (75 min)

Prerequisites
none

Competence Goal
The lecture will first address relevant microtechnical manufacturing methods. Then, selected biomedical applications will be presented, as the increasing use of microstructures and microsystems in Life-Sciences und in medicine leads to improved medico-technical products, instruments, and operation and analysis systems.

Content
Introduction into various microtechnical manufacturing methods: LIGA, Micro milling, Silicon Micromachining, Laser Microstructuring, µEDM, Metal-Etching
Biomaterials, Sterilisation.
Examples of use in the life science sector: basic micro fluidic strucutures: micro channels, micro filters, micromixers, micropumps, microvalves, Micro and nanotiter plates, Microanalysis systems (µTAS),
Lab-on-chip applications.

Workload
Literature: 20 h

Lessions: 21 h

Preparation and Review: 50 h

Exam preparation: 30 h

Literature
Menz, W., Mohr, J., O. Paul: Mikrosystemtechnik für Ingenieure, VCH-Verlag, Weinheim, 2005

M. Madou
Fundamentals of Microfabrication
Taylor & Francis Ltd.; Auflage: 3. Auflage. 2011

M 6.19 Module: BioMEMS - Microsystems Technologies for Life Sciences and Medicine II [M-MACH-100490]

Responsible: Prof. Dr. Andreas Guber
Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-MACH-100967	BioMEMS - Microsystems Technologies for Life-Sciences and Medicine II	4 CR	Guber

Competence Certificate
Written exam (75 min)

Prerequisites
None

Competence Goal
The lecture will first shortly address some relevant microtechnical manufacturing methods. Then, selected biomedical applications will be presented, as the increasing use of microstructures and microsystems in Life-Sciences und in medicine leads to improved medico-technical products, instruments, and operation and analysis systems.

Content
Examples of use in Life-Sciences and biomedicine: Microfluidic Systems:
LabCD, Protein Cristallisation
Microarrys
Tissue Engineering
Cell Chip Systems
Drug Delivery Systems
Micro reaction technology
Microfluidic Cells for FTIR-Spectroscopy
Microsystem Technology for Anesthesia, Intensive Care and Infusion
Analysis Systems of Person´s Breath
Neurobionics and Neuroprosthesis
Nano Surgery

Workload
Literature: 20 h

Lessions: 21 h

Preparation and Review: 50 h

Exam preparation: 30 h

Literature
Menz, W., Mohr, J., O. Paul: Mikrosystemtechnik für Ingenieure, VCH-Verlag, Weinheim, 2005

Buess, G.: Operationslehre in der endoskopischen Chirurgie, Band I und II;
Springer-Verlag, 1994

M. Madou
Fundamentals of Microfabrication

M 6.20 Module: BioMEMS - Microsystems Technologies for Life Sciences and Medicine III [M-MACH-100491]

Responsible: Prof. Dr. Andreas Guber
Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-MACH-100968	BioMEMS - Microsystems Technologies for Life-Sciences and Medicine III	4 CR	Guber

Competence Certificate
Written exam (75 min)

Prerequisites
none

Competence Goal
The lecture will first shortly address some relevant microtechnical manufacturing methods. Then, selected biomedical applications will be presented, as the increasing use of microstructures and microsystems in Life-Sciences und in medicine leads to improved medico-technical products, instruments, and operation and analysis systems.

Content
Examples of use in minimally invasive therapy
Minimally invasive surgery (MIS)
Endoscopic neurosurgery
Interventional cardiology
NOTES
OP-robots and Endosystems
License of Medical Products and Quality Management

Workload
Literature: 20 h

Lessions: 21 h

Preparation and Review: 50 h

Exam preparation: 30 h

Literature
Menz, W., Mohr, J., O. Paul: Mikrosystemtechnik für Ingenieure, VCH-Verlag, Weinheim, 2005

Buess, G.: Operationslehre in der endoskopischen Chirurgie, Band I und II;
Springer-Verlag, 1994

M. Madou
Fundamentals of Microfabrication

M 6.21 Module: Business Innovation in Optics and Photonics [M-ETIT-101834]

Responsible: Prof. Dr. Werner Nahm
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-104572	Business Innovation in Optics and Photonics	4 CR	Nahm

Competence Certificate
Type of Examination: examination of another type

Duration of Examination: 4 group presentations à 20 minutes (approx.)

Modality of Exam: The exam consists of four group presentations. 2nd day: Technology Presentation. 3rd day: Development plan presentation. 4th day: Business Canvas presentation. Final presentation at Zeiss visit: Business pitch

Prerequisites
Good knowledge in optics & photonics.

Competence Goal
The student has an understanding how innovative concepts for optical and photonics products are transferred into a successful business development. The student knows about and makes first hands on experiences on business development aspects in a technology start up environment. The students acquire specialized knowledge in technologies and applications in the field of smart mobile solutions for optical applications as well as an introduction into the field of patent rights.

The students can organize themselves in groups and distribute and execute tasks. Further they gain competences in the fields teamwork, organization and communication.

The studetns

- understand the implications of intellectual property
- are able to perform data base research
- know how to develop a business plan
- get an understanding of how to design a project
- are able to develop in small groups innovative business cases for a potential future product

Content
This course is instructed and presented by external innovation specialists of the R&D, business and management departments of the Carl Zeiss AG.

- Introduction: Examples of existing smart mobile device applications, Brainstorming for ideas
- Technology Introduction: Mobile device technology, Optic components, Display technology (LCD, OLED), Tracking and Sensor Technologies in smart mobile devices
- Group Work Technology
- Group Presentations Technology
- Business Case Development/ Business Plan: Market segmentation, Market research, Essentials of finance, How to write a business plan?
- Management of Intellectual Property (IP): Importance of IP Management, Patent research, Patent claims, Licencing, Patent infringement, Patent litigation
- Project Design: How to run an agile R&D Project?, Traget costing, Networked product development
- Agile project simulation
- Group Work
- Excursion to Carl Zeiss AG in Oberkochen (full day)
- Presentation of results of the group work to the new business experts committee of the Carl Zeiss AG

Module grade calculation
The final grade is the weighted average of the gradings for the four presentations. The three intermediate presentations are each weighted 1, the final presentation is weighted 3.

Workload
total 120 h, thereof 34 h contact hours and 86 h preparation, homework, self-studies and excursion

M 6.22 Module: Channel Coding: Algebraic Methods for Communications and Storage [M-ETIT-105616]

Responsible: Prof. Dr.-Ing. Laurent Schmalen
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-111244	Channel Coding: Algebraic Methods for Communications and Storage	3 CR	Schmalen

Competence Certificate
The exam is held as an oral exam of approx. 20 min.

Competence Goal
The students are able to analyse and assess problems of algebraic channel coding. They can apply methods of algebraic coding theory in the context of communication systems for data transmission and data storage and are able to assess their implementation.Additionally, they will get knowledge to current research topics and research results.

Content
This course focuses on the formal and mathematical basics for the design of coding schemes in digital communication systems. These include schemes for data transmission, data storage and networking. The course starts by introducing he necessary fundamentals of algebra which are then used to derive codes for different applications. Besides codes that are important for data transmission appliations, e.g., BCH and Reed-Solomon-Codes, we also investigate codes for the efficient storage and reconstruction of data in distributed systems (locally repairable codes) and codes that increase the throughput in computer networks (network codes). Real applications are always given to discuss practical aspects and implementations of these coding schemes. Many of these applications are illustrated by example code in software (python/MATLAB).

Module grade calculation
Grade of the module corresponds to the grade of the oral exam.

Workload

1. *Attendance to the lecture: 15 * 2 h = 30 h*
2. *Preparation and review: 15 * 4 h = 60 h*
3. *Preparation for the exam: included in preparation and review*
4. *In total: 90 h = 3 LP*

Recommendation
Knowledge of basic engineering as well as basic knowledge of communications engineering.

Previous attendance of the lectures "Communication Engineering I" and "Probability Theory" is recommended.

6.23 Module: Channel Coding: Graph-Based Codes [M-ETIT-105617]

Responsible: Prof. Dr.-Ing. Laurent Schmalen
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-111245	Channel Coding: Graph-Based Codes	6 CR	Schmalen

Competence Certificate
The success control takes place in the form of an oral examination lasting 25 minutes. Before the examination, there is a preparation phase of 30 minutes in which preparatory tasks are solved.

Prerequisites
none

Competence Goal
Students will be able to understand and apply advanced and modern methods of channel coding. They get to know various tools of modern coding theory for the analysis and optimization of coding schemes, conceptual design approaches of error correction building blocks as well as applications in digital communications (for example, 5G). Additionally, they will get knowledge to current research topics and research results.

Content
The course expands on the topics dealt with in the lecture “Verfahren der Kanalcodierung”. The focus is on modern methods that have been brought into practice in the past few years and that achieve the capacity limits postulated by Shannon. For this purpose, known techniques have to be extended and new methods have to be learnt additionally. The lecture introduces the theoretical limits very quickly and follows with a discussion on the basic concepts of channel coding, including block codes. Based on this, modern error correction methods like LDPC codes, spatially coupled codes, and Polar codes are treated in depth. The lecture ends with a view on the application of channel coding in classical and distributed storage scenarios and in computer networks. Many of the applications are illustrated with example implementations in software (python/MATLAB).

Module grade calculation
The modul grade is the grade of the oral exam.

Workload
- Lecture attendance time: 15 * 3 h = 45 h
- Presence time Exercise: 15 * 1 h = 15 h
- Lecture preparation / revision: 15 * 3 h = 45 h
- Exercise: 15 * 1 h = 15 h
- Exam preparation and attendance: 60 h

Total workload: approx. 180 h = 6 LP

Recommendation
Previous attendance of the lectures "Communication Engineering I" and "Probability Theory" is recommended. Knowledge from the lecture "Applied Information Theory" can be helpful. Previous attendance of the lecture “Verfahren der Kanalcodierung” can be helpful, but is not necessary.

M 6.24 Module: Communication Systems and Protocols [M-ETIT-100539]

Responsible: Dr.-Ing. Jens Becker
Prof. Dr.-Ing. Jürgen Becker

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-101938	Communication Systems and Protocols	5 CR	Becker, Becker

Competence Certificate
The examination consists of a written examination of 120 min.

Prerequisites
none

Competence Goal
The students are able to:

- know basic communication systems and to name them
- categorize different communication systems in regards to possible constraints
- name basic mechanisms of communication systems
- carry out these mechanisms
- choose valid mechanisms suitable under given constraints
- design a communication system adhering to constraints, specifications and be able to choose suitable methods, components, and subsystems
- know current communication systems and know about their properties, mechanisms and application.

Content
The lecture will present the physical and technical basics for the design and construction of communication systems. Procedures and technical implementations for communication between electronic devices are presented. This includes, among other things, modulation methods, line model, arbitration, synchronization mechanisms, error correction mechanisms, multiplexing, communication systems, bus systems and on-chip communication. On the basis of selected practical examples, the application of the lecture contents in real systems is demonstrated.

- Information: Definition, Representation, Communication
- Physics: Media, Signals, Mathmatical Descriptions, Line Coupling & Termination, AD Conversion & Sampling, Line Codes, Modulation
- Data Transmission: Definition & Requirements, Transmission Channels, MultiUse of Channels, Multiplexing, Multiple Senders (Arbitration), Multiple Receivers (Addressing), Classification, Interfaces
- Bus Systems: Definitions, Protocols, Transmission of Dataframes, Classification
- Error Protection: Fundamentals, Errors, Error Detection/Correction: Error Handling
- Topologies: physical, logical, examples
- Networks: networks vs. busses, structure, Network specific topologies, routing, OSI Model, TCP/IP, Ethernet
- Classification of Com.Systems
- Real World Systems: Automotive Busses, PC Busses, Field Busses, Networks

Module grade calculation
The module grade is the grade of the written exam.

Workload
The workload includes:

1. Attendance in 15 lectures an 7 exercises: 33 h
2. Preparation / follow-up: 66 h (2 h per unit)
3. Preparation of and attendance in examination: 24 h + 2 h

A total of 125 h = 5 LP

6.25 Module: Communications Engineering II [M-ETIT-105274]

Responsible: Dr.-Ing. Holger Jäkel
Prof. Dr.-Ing. Laurent Schmalen
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives (Usage until 9/30/2025)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each term	1 term	German/English	4	1

Mandatory			
T-ETIT-110697	Communications Engineering II	4 CR	Jäkel, Schmalen

Competence Certificate
The assessment will be carried out in the form of a written exam of 120 minutes.

Prerequisites
none

Competence Goal
The students are able to analyze even more complex problems in communications engineering. You can independently develop and validate solutions and use problem-solving software. The transfer of the learned methods enables the students to quickly grasp other topics and to work on them with the appropriate methodological knowledge.

Content
The course broadens the questions dealt with in the lecture Communication Engineering I. The focus here is on the detailed analysis of known algorithms and the introduction of new methods that were not discussed in the lecture Communications Engineering I, especially in the areas of system and channel modeling, equalization and synchronization.

Module grade calculation
The module grade is the grade of the written exam.

Annotation
Please note: The course "Nachrichtentechnik II" (in German) takes place every summer semester and the English version "Communications Engineering II" takes place every winter semester.

In the future, the module will be divided into an English Master's course (from winter term 25/26: Avanced Communications Engineering) and a German Bachelor's course (from summer term 2025: Nachrichtensysteme II). Both will comprise 6 CP each.

The old examination format can be taken for the last time in the first attempt in winter term 24/25. The last second attempts in SoSe 25.

Workload
1. Attendance Lecture: 15 * 2 h = 30 h
2. Preparation / Postprocessing Lecture: 15 * 4 h = 60 h
3. Presence Exercise: 15 * 1 h = 15 h
4. Preparation / follow-up Exercise: 15 * 2 h = 30 h
5. Exam preparation and presence in the same: charged in preparation / follow-up

Total: 135 h = 4 LP

Recommendation
Knowledge of basic engineering mathematics including integral transformations and probability theory as well as basic knowledge of communications engineering.

Previous visit to the lecture "Communications Engineering I", "Probability Theory" and "Signals and Systems" is recommended.

6.26 Module: Communications Engineering Laboratory [M-ETIT-100442]

Responsible: Dr.-Ing. Holger Jäkel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each term	1 term	German	4	1

Mandatory			
T-ETIT-100746	Communications Engineering Laboratory	6 CR	Jäkel

Prerequisites
none

6.27 Module: Components of Power Systems [M-ETIT-106689]

Responsible: Prof. Dr.-Ing. Thomas Leibfried
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-113445	Components of Power Systems	3 CR	Leibfried

Competence Certificate
The examination takes place in form of an oral examination lasting approx. 20 minutes.

Prerequisites
none

Competence Goal
Students know the main components of electrical networks and how they interact. Students understand the structure of cable systems in AC and DC voltage technology. The procedure for insulation coordination and overvoltage protection in the high-voltage grid is introduced. They will be able to reproduce key relationships. Students are familiar with the future challenges and trends for selected components and transmission technologies of electrical grids.

Content

- Substations
  o Types of Substations
  o Basic Requirements ans Standardization
  o Air Insulated Switchgears
  o Gas Insulated Switchgears
- Principle of Inductive Equipments
  o Magnetic Field in an Iron Circuit
  o Basic Design of Transformers
- Transformers
  o Overview
  o Design and Components of Power Transformers and Reactors
- Overhead Transmission Lines
  o Development of overhead lines system voltages
  o Grid Development with OVH Transmission Lines
  o Parts of an Overhead Line
  o Comparison DC and AC OVH Transmission Lines
  o Effects of OHL on Environment
- Cables
  o Development of Cable Lines System Voltages
  o Grid Development with cable systems
  o Parts of Cables Systems
  o Comparison DC and AC Cables Systems
  o Offshore Cables Systems
  o Effects of Cables on Environment
- Insulation Arresters
  o Insulation Coordination
  o Surge Arresters
- Circuit Breaker and Disconnectors
  o Circuit Breakers
  o Disconnectors
- Power Cable Accessories and Power Line Monitoring
  o Accessories
  o Power Line Monitoring
- Application of Power Electronics in Power System
  o Development of Power Electronics
  o Fundamental Principles of PE
  o Application of PE in Power System
- Energy Innovation and Trends

Module grade calculation
The module grade is the grade of the oral exam.

Workload
The workload includes:

1. attendance in lectures: 30 h
2. preparation / follow-up and preparation of and attendance in examination: 60 h

A total of 90 h = 3 CR

M 6.28 Module: Computational Imaging [M-INFO-106190]

Responsible: Prof. Dr.-Ing. Jürgen Beyerer
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-INFO-112573	Computational Imaging	5 CR	Meyer

Competence Certificate
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
Qualification goal: Students are able to model questions of machine vision optically and algorithmically and to process them using holistic optimization.

Learning objectives: Students know
- the essential components of machine vision, their optical modelling and suitable coding methods in the sense of computational imaging,
- methods for emitting, capturing and processing light fields for applications in photography and industrial image processing,
- the concept of light transport analysis, corresponding modelling, capturing and processing methods and
- approaches to holistic modelling and optimization of optical image capturing and processing systems.

Content
Digital image acquisition and processing have revolutionized various fields of applications, e.g., medical imaging or automated visual inspection. Yet, the design of most such systems is still based on the separate and individual optimization of the employed illumination, image acquisition and image processing components. By following a holistic approach for system design, modelling and optimization, computational imaging methods yield superior performance with respect to the state of the art. After introducing the students into relevant basics of optics and signal theory, the lecture will thoroughly cover various topics of computational imaging. Accompanying practical exercises will complement the theoretical part of the lecture. The course will enable students to adequately model artificial vision problems in the sense of computational imaging in order to obtain holistically optimal solutions.

Workload
Lecture with 2 SWS + 1 SWS exercise
5 ECTS corresponds to approx. 150 hours
approx. 30 hours lecture attendance,
approx. 15 hours exercise attendance,
approx. 90 hours post-processing and working on the exercises
approx. 30 hours Exam preparation

Literature
- Ayush Bhandari, Achuta Kadambi, Ramesh Raskar, Computational Imaging, MIT Press, 2022.
- Jürgen Beyerer, Fernando Puente León, Christian Frese, Machine Vision, Springer, 2015.
- Joseph. W. Goodman, Introduction to Fourier Optics. 4. Auflage W. H. Freeman, 2017.

M 6.29 Module: Computational Intelligence [M-MACH-105296]

Responsible: apl. Prof. Dr. Ralf Mikut
apl. Prof. Dr. Markus Reischl
Organisation: KIT Department of Mechanical Engineering
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-MACH-105314	Computational Intelligence	4 CR	Meisenbacher, Mikut, Reischl

Competence Certificate
A performance assessment is obligatory and can be oral, a written exam, or of another kind.

Prerequisites
None

Competence Goal
The students are able to apply the fundamental methods of computational intelligence (fuzzy logic, artificial neural networks, evolutionary algorithms) efficiently. They know the basic mathematical foundations and are able to transfer these methods to practical applications.

Content

- Terms and definitions Computational Intelligence, application fields and examples
- Fuzzy logic: fuzzy sets; fuzzification and membership functions; inference: T-norms and -conorms, operators, aggregation, activation, accumulation; defuzzification methods, structures for fuzzy control
- Artificial Neural Nets: biology of neurons, Multi-Layer-Perceptrons, Radial-Basis-Function nets, Kohonen maps, training strategies (Backpropagation, Levenberg-Marquardt)
- Evolutionary Algorithms: Basic algorithm, Genetic Algorithms and Evolution Strategies, Evolutionary Algorithm GLEAM, integration of local search strategies, memetic algorithms, application examples
- Deep Learning: History, Architectures, Training strategies, Interpretability and Explainable AI, Use Cases

Workload
The work load is about 120 hours, corresponding to 4 credit points.

Learning type
Lecture

M 6.30 Module: Control of Linear Multivariable Systems [M-ETIT-100374]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100666	Control of Linear Multivariable Systems	6 CR	Kluwe

Competence Certificate
Success is checked as part of a written overall test (120 minutes) of the course.

Prerequisites
none

Competence Goal
- The students first acquired basic knowledge of the various forms of description of linear multivariable systems in the frequency and time domain with both time-continuous and time-discrete models.

- In particular, they are able to transform multi-size systems in the state space to different normal forms depending on the requirements.

- The students have an understanding of fundamental properties such as Stability, trajectory profiles, controllability and observability as well as pole / zero configuration are achieved and the systems can analyze them accordingly.

- You master the basic principles for controlling linear multi-variable systems both in the frequency domain (series decoupling) and in the time domain (pole specification with pre-filter)

- In concrete terms, the students are familiar with the design procedures modal control, decoupling control in the time domain and the complete modal synthesis.

- You are familiar with the problem of state quantity determination by state observers and the design of complete and reduced observers.

- Students are able to use advanced concepts such as output feedback and dynamic controllers if necessary.

- You can continue to counter the problems of high model orders in the state space by reducing the order based on the dominance analysis.

Content
The aim is to impart basic and advanced methods for the treatment of linear multi-size systems, the focus being on the state space. In this way, the students are introduced to a model that allows more modern and, in particular, non-linear processes. On the one hand, the module provides a comprehensive overview of the most important aspects in the variable description of the systems and the analysis of their characteristic properties. On the other hand, all facets of the synthesis of regulations for initial and permanent disorders and the observers often required for this are conveyed.

Module grade calculation
The module grade is the grade of the written exam.

Workload
The workload includes:

Attendance time in lecture / exercise (3 + 1 SWS: 60h = 2 CP)

Preparation / follow-up lecture / exercise (90h = 3 CP)

Preparation / attendance time written exam (30h = 1 CP)

Recommendation
For a deeper understanding, basic knowledge of system dynamics and control technology is absolutely necessary, as taught in the ETIT Bachelor module "System Dynamics and Control Technology" M-ETIT-102181.

M 6.31 Module: Control of Power-Electronic Systems [M-ETIT-105915]

Responsible: Dr.-Ing. Andreas Liske
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-111897	Control of Power-Electronic Systems	6 CR	Liske

Prerequisites
none

M 6.32 Module: Control Technology [M-MACH-105348]

Responsible: Hon.-Prof. Dr. Christoph Gönnheimer
Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-MACH-105185	Control Technology	4 CR	Gönnheimer

Competence Certificate
Written Exam (60 min)

Prerequisites
None

Competence Goal
The students …

- are able to name the electrical controls which occur in the industrial environment and explain their function.
- can explain fundamental methods of signal processing. This involves in particular several coding methods, error protection methods and analog to digital conversion.
- are able to choose and to dimension control components, including sensors and actors, for an industrial application, particularly in the field of plant engineering and machine tools. Thereby, they can consider both, technical and economical issues.
- can describe the approach for projecting and writing software programs for a programmable logic control named Simatic S7 from Siemens. Thereby they can name several programming languages of the IEC 1131.

Content
The module control technology gives an integral overview of available control components within the field of industrial production systems.
The first part of the module deals with the fundamentals of signal processing and with control peripherals in the form of sensors and actors which are used in production systems for the detection and manipulation of process states.
The second part handles with the function of electric control systems in the production environment. The main focus in this chapter is laid on programmable logic controls, computerized numerical controls and robot controls. Finally the module ends with the topic of cross-linking and decentralization with the help of bus systems.
The module is very practice-oriented and illustrated with numerous examples from different branches.

The following topics will be covered:

- Signal processing
- Control peripherals
- Programmable logic controls
- Numerical controls
- Controls for industrial robots
- Distributed control systems
- Field bus
- Trends in the area of control technology

Workload
regular attendance: 21 hours
self-study: 99 hours

Learning type
Lecture

6.33 Module: Control Theory Laboratory [M-ETIT-105467]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each term	1 term	German	4	1

Mandatory			
T-ETIT-111009	Control Theory Laboratory	6 CR	Hohmann

Prerequisites
None

M 6.34 Module: Cryogenic Engineering [M-CIWVT-104356]

Responsible: Prof. Dr.-Ing. Steffen Grohmann
Organisation: KIT Department of Chemical and Process Engineering
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-CIWVT-108915	Cryogenic Engineering	6 CR	Grohmann

Competence Certificate
The examination is an oral examination with a duration of about 30 minutes (section 4 subsection 2 number 2 SPO).

Prerequisites
None

Competence Goal
Understanding the principle and modelling of regenerative cryocoolers; Understanding and applying of essential engineering methods and components for the conception and design of low-temperature plants and cryostat systems; Understanding of laboratory measurement principles, assessing and applying of sensors and instruments for cryogenic measurement tasks and analysing of measurement uncertainties

Content
Cryogenic applications; Regenerative cooling with cryocoolers; Fundamentals of low-temperature plant and cryostat design, including fluid mechanics and heat transfer, thermal contacts and thermal insulation, cryogenic pumping of gasses, regulations, design components and safety; General principles of measurement and uncertainties as well as cryogenic temperature, pressure and flow measurement

Module grade calculation
The grade of the oral examination is the module grade.

Workload

- Attendance time (Lecture): 45 h
- Homework: 45 h
- Exam Preparation: 90 h

M 6.35 Module: Cryptographic Protocols [M-INFO-105631]

Responsible: Prof. Dr. Jörn Müller-Quade
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each summer term	1 term	German	4	2

Mandatory			
T-INFO-111261	Cryptographic Protocols	5 CR	Geiselmann, Müller-Quade

M 6.36 Module: Current Topics of Solar Energy [M-ETIT-100507]

Responsible: Prof. Dr.-Ing. Michael Powalla
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100780	Current Topics of Solar Energy	3 CR	Powalla

Prerequisites
none

M 6.37 Module: Cyber Physical Production Systems [M-ETIT-106039]

Responsible: Prof. Dr.-Ing. Mike Barth
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-112223	Cyber Physical Production Systems	4 CR	

Competence Certificate
The examination takes place within the framework of an oral overall examination (20 minutes).

Prerequisites
none

Competence Goal

- The students are familiar with the aspects of Industrie 4.0 and the associated cyber-physical production systems.
- Students will be able to network machines and industrial control systems with each other.
- Students understand the need for advanced methods and services in the field of industrial automation.
- Students are able to model mechatronic production systems and form digital assets.
- Students are able to validate different information models and ontologies for their applicability.
- Students will be able to model data, information and knowledge or extract them from existing systems.
- Students are able to apply artificial intelligence methods in the domain of systems engineering.
- Students are able to conceptualize the networking of machines.
- The students know suitable modeling tools and their application.

Content

- This module is designed to teach students the theoretical and practical aspects of Industrie 4.0.
- This module further provides a definition of the asset admibistration shell as well as other information models in industrial application.
    - AutomationML
    - Petri nets
    - PLCOpenXML
- Aspects of Cyper Physical Production Systems will be covered as well as their networking in the Industrial Internet of Things.
- Students will learn common IoT protocols such as OPC UA and MQTT.
- The module aims to provide students with an understanding of the basic principles and limitations of artificial intelligence in industrial automation technology.
- The module shows the relevance of the digital twin and the information modeling behind it.
- The module teaches the aspects of the Semantic Web including ontologies and RDF.
- The students learn formal description languages of automation technology.
- The students learn the aspects of the reliability of networked automation systems regarding functional and IT security.
- The module teaches advanced methods of software engineering and architectures for automation technology.

Module grade calculation
The module grade is the grade of the oral exam.

Workload
The workload includes:

1. attendance in lectures an exercises: 15*2 h = 30 h
2. preparation / follow-up: 15*4 h = 60 h
3. Preparation of the CPS-Demos: 30 h
4. preparation of and attendance in the final presentation: included in preparation and follow-up.

A total of 120 h = 4 CR

Recommendation
Enjoyment and interest in industrial production and automation. Fun with digitalization and virtual engineering in particular. No inhibitions about software and data models.

M 6.38 Module: Cyber-Physical Modeling [M-ETIT-106953]

Responsible: Prof. Dr.-Ing. Mike Barth
Prof. Dr.-Ing. Sören Hohmann

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Field of Specialization / Automation, Robotics, and Systems Engineering

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-113908	Cyber-Physical Modeling	6 CR	Barth, Hohmann

Competence Certificate
The examination takes place in the form of a written examination lasting 90 min.

Prerequisites
none

Competence Goal

- The students are familiar with the concepts of Cyber-Physical System.
- Students understand the need for advanced methods and services in the field of automation.
- Students can validate different information models and ontologies for their applicability in CPS.
- Students will be able to model data, information and knowledge or extract them from existing systems.
- The students know suitable modeling tools and their application.
- The students understand the general model concept as well as the characteristics of physical and data-based modeling and can describe their differences.
- They can structure complex systems and systematically analyze dependencies of subsystems.
- They can explain the general procedure of physical and data-based modeling, apply it to technical systems, and analyze the results.
- They can apply causal and non-causal modeling approaches and distinguish between them.
- Students have gained an understanding of generalized, cross-domain, physical relationships and can develop models for electrical, mechanical, pneumatic and hydraulic systems.
- They can describe the relationship between generalized, cross-domain, physical models and basic procedures of physical-based control and explain their advantages / limitations based on basic knowledge of control engineering.
- The students can estimate and judge the effects of disturbances and real conditions on the identification results.

Content
This course aims at engineering students that focus on a system-based engineering curriculum, including architectures, modeling & simulation for Cyber Physical Systems. The module is designed to teach students the theoretical and practical aspects of Digital Twins and their interconnection with their physical counterpart. It encompasses fundamental topics along the complete process of modeling technical systems. For this purpose, it includes the conception and construction of digital twins including their model components. In terms of modeling and simulation of physical systems, two major areas will be covered: On the one hand, physical-based modeling techniques which derive formal model equations based on analyzing the physical first-principles of technical systems. This includes, inter alia, generalized equivalent circuits, bond graphs, port-Hamiltonian systems, variational analysis (Euler-Lagrange of the first kind). Selected topics of physical-based control methods will also be briefly introduced to integrate the complete physical control design in the wider control context and highlight its possible benefits. On the other hand, data-based identification techniques will be covered which are used to identify concrete model parameters for a given technical system from experimental data sets. When combining the identification with an initial, non-physical, structural set up of model equations, the complete process is often referred to as data-based modeling or black-box modeling. Both modeling areas base on available information about the physical system which is structured in Meta- and Information-Models. Examples that are covered in this lecture are Metamodels, e.g. AutomationML or the asset administration shell principles. Also, semantic web principles and ontologies will be part of the lecture content.

Module grade calculation
The module grade is the grade of the written exam.

Workload

1. attendance in lectures an exercise: 3+1 SWS (60 h)
2. pre-/postprocessing of the lecture (90 h)
3. preparation of and attendance in the exam: (30 h)

   A total of 180 h = 6 CR

Recommendation
Interest in Modeling and Simulation of modern Cyber-Physical Systems in combination with concepts of digital twins, system architectures and Co-Simulation.
Sound understanding of engineering mechanics, electrical, mechatronic systems / physics / Software-Engineering should be fulfilled to successfully attend the lecture, exercise tasks / case studies, and exam.

M 6.39 Module: Data Science [M-INFO-106505]

Responsible: Prof. Dr.-Ing. Klemens Böhm
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	2 terms	German	4	1

Mandatory			
T-INFO-113124	Data Science	8 CR	Böhm

M 6.40 Module: Deep Learning and Neural Networks [M-INFO-104460]

Responsible: Prof. Dr. Jan Niehues
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-INFO-109124	Deep Learning and Neural Networks	6 CR	Niehues

Competence Certificate
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
Students will learn about the structure and function of different types of neural networks.

Students should learn the methods for training the various networks and their application to problems.

Students should learn the areas of application of the different types of networks.

Given a concrete scenario, students should be able to select the appropriate type of neural network.

Content
This module introduces the use of neural networks for the solution of solving various problems in the field of machine learning, such as classification, prediction, control or inference. or inference. Different types of neural networks are covered and their areas of application are illustrated using examples.

Workload
180h.

Recommendation
Prior successful completion of the core module "Cognitive Systems" is recommended.

M 6.41 Module: Deep Learning for Computer Vision I: Basics [M-INFO-105753]

Responsible: Prof. Dr.-Ing. Rainer Stiefelhagen
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German/English	4	1

Mandatory			
T-INFO-111491	Deep Learning for Computer Vision I: Basics	3 CR	Stiefelhagen

Competence Goal
Students should be able to grasp the underlying concepts in the field of deep learning and its various applications.

- Understand the theoretical basis of deep learning
- Understand the Convolutional Neural Networks (CNN)
- Develop basis for the concepts and algorithms used in building and training the CNNs.
- Able to apply deep learning in different computer vision applications.

Content
In recent years tremendous progress has been made in analysing and understanding image and video content. The dominant approach in Computer Vision today are deep learning approaches, in particular the usage of Convolutional Neural Networks.

The lecture introduces the basics, as well as advanced aspects of deep learning methods and their application for a number of computer vision tasks. The following topics will be addressed in the lecture:

- Introduction to Deep Learning
- Convolutional Neural Networks (CNN): Background
- CNNs: basic architectures and learning algorithms
- Object Recognition with CNN
- Image Segmentation with CNN
- Recurrent Neural Networks
- Generating image descriptions (Image Captioning)
- Automatic question answering (Visual Question Answering)
- Generative Adversarial Networks (GAN) and their applications
- Deep Learning platforms and tools

Annotation
The course is partially given in German and English.

M 6.42 Module: Deep Learning for Computer Vision II: Advanced Topics [M-INFO-105755]

Responsible: Prof. Dr.-Ing. Rainer Stiefelhagen
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German/English	4	3

Mandatory			
T-INFO-111494	Deep Learning for Computer Vision II: Advanced Topics	3 CR	Stiefelhagen

M 6.43 Module: Design and Architectures of Embedded Systems (ES2) (24106) [M-INFO-100831]

Responsible: Prof. Dr.-Ing. Jörg Henkel
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-INFO-101368	Design and Architectures of Embedded Systems (ES2)	3 CR	Henkel

Competence Certificate
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
The student learns methods for mastering complexity and applies these methods to the design of embedded systems. He/she evaluates and selects specific architectures for embedded systems. Furthermore, the student receives an introduction to current research topics.

Content
Nowadays, it is possible to integrate several billion transistors on a single chip and thus realize complete SoCs (systems-on-chip). The trend towards being able to use more and more transistors continues unabated, meaning that the complexity of such systems will also continue to increase. Computers will increasingly be ubiquitous, i.e. they will be integrated into the environment and will no longer be perceived as computers by humans. Examples include sensor networks, electronic textiles and many more. However, the physically possible complexity will not be readily achievable in practice, as there is currently a lack of powerful design processes capable of handling this high level of complexity. Powerful ESL tools ("Electronic System Level Design Tools") and novel architectures will be required. The focus of this lecture is therefore on high-level design methods and architectures for embedded systems. Since the power consumption of (mostly mobile) embedded systems is of crucial importance, one focus of the design methods will be on the design with regard to low power consumption.

Workload
90h

6.44 Module: Design of Electrical Machines [M-ETIT-100515]

Responsible: Prof. Dr. Martin Doppelbauer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	German	4	2

Mandatory			
T-ETIT-100785	Design of Electrical Machines	5 CR	Doppelbauer

Prerequisites
none

Recommendation
Modul: Elektrische Maschinen und Stromrichter

M 6.45 Module: Detectores for Applications in Space and Astronomy [M-ETIT-100541]

Responsible: Prof. Theo Scherer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100761	Detectors for Applications in Space and Astronomy	3 CR	Scherer

Prerequisites
none

6.46 Module: Digital Beam-Forming for Imaging Radar [M-ETIT-105415]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-110940	Digital Beam-Forming for Imaging Radar	4 CR	Zwick

Competence Certificate
The examination consists of a written exam (approx. 120 min.) and weekly excercises. The overall impression is rated.

Prerequisites
The lecture builds upon Spaceborne Radar Remote Sensing (engl.). The basic principles will be repeated in the lecture. The following lectures are helpful for a comprehensive understanding: Radar System Engineering (engl.), Antennen und Mehrantennensysteme, , Modern Radio System Engineering (engl.).

Competence Goal
Students have a basic knowledge of antenna arrays, radar, multipath propagation and noise. They understand the principle and functionality of beam shaping and the differences between digital, analog and hybrid beam-forming. They know the theory, methods, and algorithms of beam-forming. They can understand how beam-forming is applied to radar. You can explain basic radar system concepts and summarize the various applications.

Content
The lecture is (inherently) interdisciplinary and ideally suited to teach students the combination if signal processing for imaging radar and digital beam-forming. The basic knowledge about antennas & antenna arrays, radar ambiguities and noise is explained in the lecture. This is followed by a details on various beam forming algorithms with reference to imaging radar systems and with application examples from spaceborne synthetic aperture radar (SAR). Aspects such as digital and hybrid beam forming, as well as MIMO and equivalent virtual antenna configuration are explained. Lecture notes (english) are offered to the participants to consolidated the study material.

The lecture is be accompanied by exercises on the lecture material. These are discussed in a room exercise and the associated solutions are presented in detail.

Module grade calculation
The module grade results of the assessment of the written exam and the weekly excercises. Details will be given during the lecture.

Workload
- Attendance time in lectures (1.5 h per 15 dates) and exercises (1.5 h per 7 dates) = 33 h
- Preparation / revision: 15 weeks each 3 h = 45 h
- Exam preparation and presence in the exam: 1 week à 40 h = 40 h
- Total effort approx. 120 hours = 4 LP

Recommendation
Basics of signal processing and radar techniques are useful.

M 6.47 Module: Digital Circuit Design [M-ETIT-100473]

Responsible: Prof. Dr. Ivan Peric
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100974	Digital Circuit Design	4 CR	Peric

Annotation
Will be changed to English in summer term 25.

M 6.48 Module: Digital Hardware Design Laboratory [M-ETIT-102264]

Responsible: Prof. Dr.-Ing. Jürgen Becker
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-104570	Digital Hardware Design Laboratory	6 CR	Becker

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-ETIT-102266 - Digital Hardware Design Laboratory must not have been started.

M 6.49 Module: Digital Hardware Design Laboratory [M-ETIT-102266]

Responsible: Prof. Dr.-Ing. Jürgen Becker
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-104571	Digital Hardware Design Laboratory	6 CR	Becker

Competence Certificate
Control of success is carried out in an oral examination as well as during the laboratory exercises in form of laboratory reports and/or oral interrogations.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-ETIT-102264 - Digital Hardware Design Laboratory must not have been started.

Competence Goal
The students

- know the practical usage of FPGAs
- are able to efficiently use modern hardware development tools
- know how to describe hardware in VHDL
- can self dependently draft and implement VHDL-Components based on given specifications
- are able to practically apply common concepts and principles in hardware development (e.g. pipelining)

Content
Grouped in teams of two, the students are introduced to the design of complex hardware/software systems. The laboratory takes place in weekly 4 hour laboratory sessions. During the first few sessions, the students are introduced to the implementation of VHDL-components, the usage of modern synthesis and simulation tools as well as basic knowledge on FPGAs.

Based on those fundamentals, students develop the different components of an image processing system in the second part of the laboratory. This includes implementation and testing steps for the individual components as well as the integration to an overall system. Finally, the hardware system can be realized on FPGA-Hardware and tested with live camera images.

Module grade calculation
The module grade is composed of the result of the oral examination and the effected performance during the laboratory sessions (e.g. reports, oral interrogations, etc.).

Annotation
The module ETIT-102264 („Praktikum Entwurf digitaler Systeme“) must not have been started or completed.

Workload
The amount of work is distributed as follows:

- time of presence during the laboratory sessions: 11 sessions with 4h = 44h
- Preparation and wrap-up: 6h per laboratory session = 66h
- Preparation for the examination: 40h

In total 150h (25h per credit point).

Recommendation
Previous knowledge in design and design automation for electronic systems (e.g. from the lectures HSO, No. 2311619 or HMS, No. 2311608) is recommended.

M 6.50 Module: Digital Real Time Simulations for Energy Technologies [M-ETIT-106690]

Responsible: Prof. Dr.-Ing. Giovanni De Carne
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-113449	Digital Real Time Simulations for Energy Technologies	3 CR	De Carne

Competence Certificate
The examination takes place in form of other types of examination. It consists of an assessment from an exercise on HiL and an oral overall examination (approx. 15 minutes) explaining the exercise results. The overall impression is evaluated.

Prerequisites
none

Competence Goal
To give bachelor’s and master’s degree students an overview of the need, concept, implementation and execution of Hardware in the Loop (HiL) testing. At the end of the course:

- The students will be able to understand the setup of HiL systems (Device Under Tests, Real Time simulator, I/O, power amps for PHiL, interfacing principles and techniques)
- The students will be able to devise HiL test cases, creating models with an understanding of the trade-off between simulation fidelity and computational resources.
- The students can interface Device Under Tests, running Real Time simulations and executing tests.
- The students are able to perform an independent HiL project and deliver HiL experimental results.

Content
Lesson 1: Introduction

- Overview of control system development process (V-cycle and variants).
- Real-time simulation concept – What does it mean simulating in real time?
- Basic concepts of Real Control Prototyping and Control-Hardware in the Loop.
- Basic concept of Power-HiL

Lesson 2: Introduction to real time simulation (1/2)

- Initial definitions for real time simulations: Wall-clock time, simulation time, hard real-time and soft real-time.
- Off-line simulation software solvers
- Numerical integration, DAE solvers, numerical stability. Complexities induced by switches.
- Distinctions between state-space based and nodal approach-based solvers for CPU
- Difference between CPU and FPGA modeling
- Numerical examples & practical implementation of solvers

Lesson 3: Modelling in real time: grid modelling

- Modeling for HiL, level of model detail vs computational performance
- problems with parallelization due to latencies in transferring data, I/O latency considerations.
- Introducing transmission line decoupling, stublines, ITM and other techniques
- Introducing the State-Space Nodal approach

Lesson 4: Modelling in real time: power electronics

- Modelling components for fast transients (e.g, switches), average models, full switching models
- Interface FPGA-based with CPU-based modelling
- Practical examples and applications

Lesson 5: Modelling in real time: multi-time-scale networks

- Modeling for HiL: different time-scales phasor/RMS, EMT, fast EMT on FPGA.
- Stability issues associated with multi-time-scale hybrid simulation (e.g. RMS/EMT or EMT on CPU and FPGA.
- Multi-time-scale simulation with phasor/EMT/FPGA

Lesson 6: Rapid Control Prototyping (RCP)

- Main Concept and benefits from RCP, Applications
- Generating a code from Simulink and implementation in the real time simulator
- FPGA-based RCP, Datalogging
- Demonstration in classroom

Lesson 7: Controller Hardware In the Loop

- Definition of HIL and testing opportunities
- Analog and digital I/O in real time simulators
- Designing an HiL test – identifying controller functionality to be tested, creating appropriate model and test sequences, identifying potential failures and testing in failure/off-design conditions, use of test automation

Lesson 8: Power Hardware In the Loop

- Introduction to PHIL
- PHIL equipment: power amplifiers. 2Q/4Q applications, specifying power amplifiers
- Interface algorithms between Real Time Simulation and the Device Under Test
- Stability vs. interface accuracy, current state of the art
- Impedance-based stability analysis

Module grade calculation
The module grade results of the assessment of an exercise and the oral exam. Details will be given during the lecture.

Workload
The workload includes (2 SWS):

attendance in lectures and exercises: 15*2 h = 30 h
preparation / follow-up: 15*4 h = 60 h
final project, preparation of and attendance in examination: 30 h
A total of 120 h = 4 CR

Recommendation

- Good knowledge of power electronics, linear control theory, and power systems is required.
- Good knowledge of Matlab/Simulink simulation environment is required.

6.51 Module: Digital Signal Processing in Optical Communications – with Practical Exercises [M-ETIT-103450]

Responsible: Prof. Dr.-Ing. Sebastian Randel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	2

Mandatory			
T-ETIT-106852	Digital Signal Processing in Optical Communications – with Practical Exercises	6 CR	Randel

Competence Certificate
The exercise sheets and the oral questionnaire are used to rate other types of examinations. The overall impression is assessed. Duration about 20 minutes.

Prerequisites
Basic knowledge of optical communication systems. Proven, for example, by completing one of the modules "Optical Networks and Systems-ONS", "Optoelectronic Components -OC, or" Optical Transmitters and Receivers - OTR.

Competence Goal

- The students understand the functioning of modern optical communication systems, which combine electro-optical technologies with digital signal processing.
- You are able to independently implement and test algorithms from digital signal processing as well as suitable simulation and test environments in a suitable scripting language (e.g. Matlab or. Python).
- Furthermore, they can estimate the influence of interfering effects occurring in the glass fiber such as chromatic dispersion and polarization mode dispersion.
- You are also able to estimate the complexity and power consumption of the resulting logic circuits.

Content

- The module deals with algorithms from digital signal processing that are used in broadband optical communication systems. Practical exercises in which the students implement algorithms independently form an essential part of the module.
- In lectures there will be an introduction to the development of digital coherent transmitters and receivers. Building on this, essential function blocks such as the dispersion compensation, the adaptive equalization of polarization mode dispersion as well as carrier and clock recovery are discussed.
- In the exercises, these function blocks are to be implemented in software (Matlab, Octave).
- In addition, individual examples show how digital signal processing algorithms are described in hardware (Hardware Description Language - HDL) and how their complexity scales.

Module grade calculation
The exercise sheets and the oral questioning are used to rate other types of examinations. The overall impression is assessed.

Workload
Approximately 170h workload of the student. The workload includes:

30h - attendance in lectures

30h - exercises

70h - preparation / follow-up

40h - written exercises and exam

Recommendation
Knowledge of the basics of optical communication technology and digital signal processing is helpful.

M 6.52 Module: Digital Twin Engineering [M-ETIT-106040]

Responsible: Prof. Dr.-Ing. Mike Barth
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-112224	Digital Twin Engineering	4 CR	

Competence Certificate
The examination takes place in form of other types of examination. It consists of a model library developed in the course of a semester-long project in the modeling language Modelica and a presentation of the library lasting 25 minutes. The quality of the model library is evaluated within the framework of the criteria: documentation, formal correctness, functionality, usability, HMI and modeling level of detail. The presentation is evaluated as an additional aspects. The overall impression is evaluated.

Prerequisites
none

Competence Goal

- The students will be able to analyze, structure and formally describe problems in the area of object-oriented physical system modeling.
- The students will be able to understand, apply and further develop the Modelica modeling language.
- The students are able to transfer bidirectionally acting systems into a model.
- The students are able to transfer physical equations into the modeling environment.
- The students are able to critically evaluate the different numerical integration methods for their applicability and to use them sensibly.
- The students are able to create system models and co-simulations using functional mockup units.
- The students will be able to implement a real system at the appropriate modeling depth for the task.
- The students will be able to abstract real system properties and, if necessary, decide whether they need to be modeled.
- The students know suitable simulation tools and their application.

Content

- This module is designed to provide students with the theoretical and practical aspects of object-theoretic equation-based modeling.
- This module also provides a definition of the digital twin and its aspects of the management shell.
    - In this context, a classification of simulation models in the I4.0 VWS takes place.
- Both system simulation in the Open Modelica Editor (OME) and co-simulation with Functional Mockup Units (FMU) will be covered.
- Students create a new model library of a mechatronic system in a semester-long project (teams of 3-4 students).
- The module provides an overview of modern system simulation methods based on bidirectional flow and potential modeling.
- Beyond theoretical and practical modeling, the module imparts the knowledge about practice-relevant modeling levels or depths.
- Furthermore, quality standards for simulation models with focus on the engineering of plants/systems are discussed.

Module grade calculation
The assessment of the developed model library and the presentation of the library will be included in the module grade. More details will be given at the beginning of the course.

Workload
The workload includes:

1. attendance in lectures an exercises: 10*1,5 h = 15 h
2. preparation / follow-up: 15*2 h = 30 h
3. Implementation of the model library: 60 h
4. preparation of and attendance in the final presentation: 15 h

A total of 120 h = 4 CR

M 6.53 Module: Distributed Discrete Event Systems [M-ETIT-100361]

Responsible: Prof. Dr.-Ing. Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100960	Distributed Discrete Event Systems	4 CR	Heizmann

Prerequisites
none

M 6.54 Module: Dosimetry of Ionising Radiation [M-ETIT-101847]

Responsible: PD Dr. Bastian Breustedt
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-104505	Dosimetry of Ionising Radiation	3 CR	Breustedt

Competence Certificate
Success control is carried out as part of an overall written examination (2 h).

Prerequisites
none

Content
Dosimetry of ionizing radiation The lecture defines the various dose terms used to characterize radiation exposure and the underlying dosimetric system. It describes the methods and techniques of dosimetry for ionizing radiation for various applications. The topics covered are:

Ionizing radiation and interactions with matter, biological radiation effects

Characterization of radiation fields

Dose terms and your applications

Methods and techniques for external exposure dosimetry (external dosimetry)

Methods and techniques for internal exposure dosimetry (internal dosimetry)

Dosimetry applications in medicine Dosimetric laboratories at KIT

Module grade calculation
The module grade is the grade of the written exam.

Workload
The workload includes:

Attendance time in lectures (2 h 15 appointments each) = 30 h

Self-study (3 h 15 appointments each) = 45 h

Preparation / post-processing = 20 h

Total effort approx. 95 hours = 3 LP

M 6.55 Module: Electric Drives for E-Mobility [M-ETIT-106971]

Responsible: Prof. Dr. Martin Doppelbauer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-113936	Electric Drives for E-Mobility	4 CR	Doppelbauer

Competence Certificate
The success control takes place in the form of an oral examination of approximately 30 minutes.

Prerequisites
none

Competence Goal
The students will be able to assess the structure, performance and behavior of full-electric and hybrid drive systems for all types of traction applications from pedelecs to cars, utility vehicles, railroads and even large propulsion systems in ships. They can critically evaluate the different drive systems and components.

The students will be able to understand the latest developments in electric drive technology and future possibilities.

Content
This module is designed to provide students with the theoretical and practical aspects of electric drives for electric traction applications.

Table of content:

- Overview: Electric Drives in Hybrid and Electric Vehicles
- Fundamentals of Rotary Field Machines
- Fundamentals of Power Electronics
- Design of Synchronous Machines
- Design of Induction Machines
- Noise, Vibration and Harshness (NVH)
- Thermodynamics of Electric Machines

Module grade calculation
The module grade is the grade of the oral exam.

Workload
The workload includes (3 SWS):

1. attendance in lectures 15*2 h = 30 h
2. Attendance in exercises: 15*1 h = 15 h
3. preparation / follow-up: 15*3 h = 45 h
4. preparation of and attendance in examination: 30 h

   A total of 120 h

Recommendation
Basic knowledge in the field of electric machines and drives is helpful, for example by attending the course “Elektrische Maschinen und Stromrichter (EMS)” in the KIT-Bachelor.

Basic knowledge in the field of hybrid and electric vehicles is helpful, for example by attending the course “Hybridelektrische Fahrzeuge HEF)” in the KIT-Bachelor.

M 6.56 Module: Electric Power Generation and Power Grid (Sp-EPG) [M-ETIT-101917]

Responsible: Dr.-Ing. Bernd Hoferer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-103608	Electric Power Generation and Power Grid	3 CR	Hoferer

Competence Certificate
Type of Examination: oral exam

Duration of Examination: approx. 20 minutes

Prerequisites
Anyone who has completed the Electrical Power Generation (EEE) module in the Bachelor (SPO 2015 and 2018) should Master does not select the Electric Power Generation and Power Grid module.

Competence Goal
The students

- are familiar with characteristics of different types of power generation
- are able to evaluate the performance of different types of power generation
- comprehend the challenges in power transmission systems due to volatile power generation.
- can derive solutions for a future power generation pool and power grid
- are able to calculate the efficiency factor of power generation systems
- know how to apply mathematical concepts like load flow calculation and short-circuit calculations

Content
I. Energy resources and energy consumption
II. Conversion of primary energy in power plants; thermo-dynamical fundamental terms, processes in steam power plants; steam power plants components; flue gas cleaning
III. Synchronous machines
IV. Thermal power plants (fossil-fueled steam generation, nuclear-fueled steam generation)
V. Renewable energy generation (hydro-electric, wind, solar)
VI. Transmission systems (AC power transmission, DC power transmission)
VII. Load flow calculations

Module grade calculation
The module grade is the grade of the oral exam.

Workload
total 90 h, hereof 30 h contact hours and 60 h homework and self-studies

Literature
Schwab; Electric energy systems;
Fink, Beaty; Standard handbook for electrical engineers

M 6.57 Module: Electric Power Transmission & Grid Control [M-ETIT-105394]

Responsible: Prof. Dr.-Ing. Thomas Leibfried
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Fundamentals)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	2

Mandatory			
T-ETIT-110883	Electric Power Transmission & Grid Control	6 CR	Leibfried

Competence Certificate
The examination takes place in form of a written examination lasting 120 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-ETIT-105394 - Electric Power Transmission & Grid Control must not have been started.

Competence Goal
Students are familiar with the functionality and physical basics as well as the components of AC and DC of electric power transmission systems. They will be able to calculate transmission characteristics and carry out a basic design. They are also familiar with the functioning of grid control.

Content
The lecture initially deals with the characteristics and stability of electrical energy transmission. A central chapter deals with HVDC technology as a method for transmitting high power. FACTS elements, which are used to make energy transmission more flexible, are then dealt with. Finally, the dynamics of power plants and grids are discussed.

Module grade calculation
The module grade is the grade of the written exam.

Workload
The workload includes:

1. attendance in lectures and exercises: 30 + 30 h = 60 h
2. preparation / follow-up: 120 h

A total of 180 h = 6 CR

Recommendation

- Basic Knowledge in electrical network analysis
- Basic Knowledge about the functionality of electric grid components
- Basic Knowledge about the calculations of three-phase systems
- Basic Knowledge about symmetrical components, Park-transform and Clark-transform

M 6.58 Module: Electrocatalysis [M-ETIT-105883]

Responsible: Prof. Dr. Ulrike Krewer
Dr. Philipp Röse

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each summer term	1 term	English	4	3

Mandatory			
T-ETIT-111831	Electrocatalysis	5 CR	Röse

Competence Certificate
The examination takes place in form of a written examination lasting 120 minutes.

Prerequisites
none

Competence Goal
Students have a well-grounded knowledge of electrocatalytic energy technologies for the conversion and storage of electrical energy in chemicals (Power-to-X). They know the functional principle of state-of-the-art electrocatalysts in fuel cells and electrolysis and understand the underlying electrochemical and physical processes. Participation in the course enables the students to assess and understand the relationship between electrode structure and their selectivity, performance and stability. Furthermore, the students learn the theoretical basics of experimental methods that are relevant for the investigation of model electrodes and technical cells.

Content
Lecture:

- **Basics, concepts and definitions within the Power-to-X context:** Catalysis and electrocatalysis; activity and selectivity; fundamentals of electrochemical processes, elementary steps involving adsorbed intermediates.

- **The role of intermediates:** Electron transfer without intermediates, multi-electron transfer with intermediates; differences in adsorption energies of intermediates and active surfaces

- **Theoretical treatment of electron transfer reactions:** Tunneling processes at electrodes; electron transfer reactions (Marcus theory); role of electrode material on rate of electrode reaction.

- **Measurement methods for the investigation of electrocatalytic reactions:** Determination of the effective surface; Determination of the activity of electrochemically active species; Determination of the selectivity; Operando measurement methods

- **Technically important electrocatalytic reactions and processes:** The oxygen reduction reaction (ORR) and evolution reaction (OER); the chlorine evolution reaction.

Module grade calculation
The module grade is the grade of the written examination.

Workload
attendance in lectures: 30 * 45 min. = 22,5 h

attendance in exercises: 15 * 45 min. = 11,25 h

preparation and follow up of the lectures and practice: 76.25 hours (approx. 1.75 hours per lecture or exercise)

preparation of examination and attendance in examination: 40 h

A total of 150 h = 5 CR

Recommendation
The participation of the module "Electrochemical Energy Technologies" is helpful.

6.59 Module: Electromagnetics and Numerical Calculation of Fields [M-ETIT-100386]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-ETIT-100640	Electromagnetics and Numerical Calculation of Fields	4 CR	Zwick

Competence Certificate
Success control is carried out in the form of a written test of 120 minutes.

Prerequisites
none

Competence Goal
Students with very different background in electromagnetic field theory will be brought to a high level of comprehension. They will understand the concept of electric & magnetic fields and of electric potential & vector potential and they will be able to solve simple problems of electric & magnetic fields using mathematics. They will understand the equations and solutions of wave creation and wave propagation. Finally the student will have learnt the basics of numerical field calculation and be able to use software packages of numerical field calculation in a comprehensive and critical way.

The student will

- be able to deal with all quantities of electromagnetic field theory (E, D, B, H, J, M, P, ...), in particular: how to calculate and how to measure them,
- derive various equations from the Maxwell equations to solve simple field problems (electrostatics, magnetostatics, steady currents, electromagnetics),
- be able to deal with the concept of field energy density and solve practical problems using it (coefficients of capacitance and coefficients of inductance),
- be able to derive and use the wave equation, in particular: to solve problems how to create a wave and calculate solutions of wave propagation through various media,
- be able to outline the concepts, the main application areas and the limitations of methods of numerical field calculation (FDM, FDTD, FIM, FEM, BEM, MoM, TLM)
- be able to use one exemplary software package of numerical field calculation and solve simple practical problems with it.

Content

This course first gives a comprehensive recap of Maxwell equations and important equations of electromagnetic field theory. In the second part the most important methods of numerical field calculation are introduced.

Maxwell’s equations, materials equations, boundary conditions, fields in ferroelectric and ferromagnetic materials

electric potentials, electric dipole, Coulomb integral, Laplace and Poisson’s equation, separation of variables in cartesian, cylindrical and spherical coordinates

Dirichlet Problem, Neumann Problem, Greens function, Field energy density and Poynting vector,

electrostatic field energy, coefficients of capacitance, vector potential, Coulomb gauge, Biot-Savart-law, magnetic field energy, coefficients of inductance magnetic flux and coefficients of mutual inductance, field problems in steady electric currents,

law of induction, displacement current

general wave equation for E and H, Helmholtz equation

skin effect, penetration depth, eddy currents

retarded potentials, Coulomb integral with retarded potentials

wave equation for potential and Vector potential and A, Lorentz gauge, plane waves

Hertzian dipole, near field solution, far field solution

transmission lines, fields in coaxial transmission lines

waveguides, TM-waves, TE-waves

finite difference method FDM

finite difference - time domain FDTD, Yee ´s algorithm

finite difference - frequency domain

finite integration method FIM

finite element method FEM

boundary element method BEM, Method of Moments (MOM), Transmission LIne Matrix Methal (TLM),

solving large systems of linear equations

basic rules for good numerical field calculation

The lecturer reserves the right to alter the contents of the course without prior notification.

Module grade calculation

The module grade is the grade of the written exam.

Workload

Each credit point corresponds to approximately 25-30 hours of work (of the student). This is based on the average student who achieves an average performance. The workload includes:

Attendance time in lectures (3 h 15 appointments each) = 45 h

Self-study (4 h 15 appointments each) = 60 h

Preparation / post-processing = 20 h

Total effort approx. 125 hours = 4 LP

Recommendation

Fundamentals of electromagnetic field theory.

Literature

Matthew Sadiku (2001), Numerical Techniques in Electromagnetics.
CRC Press, Boca Raton, 0-8493-1395-3
Allen Taflove and Susan Hagness (2000), Computational electrodynamics: the finite-difference time-domain method.
Artech House, Boston, 1-58053-076-1
Nathan Ida and Joao Bastos (1997), Electromagnetics and calculation of fields.
Springer Verlag, New York, 0-387-94877-5
Z. Haznadar and Z. Stih (2000), Electromagnetic Fields, Waves and Numerical Methods.
IOS Press, Ohmsha, 1 58603 064 7
M.V.K. Chari and S.J. Salon (2000), Numerical Methods in Electromagnetism, Academic Press, 0 12 615760 X

M 6.60 Module: Electronic Circuits for Light Sources and Laser [M-ETIT-100511]

Responsible: Dr.-Ing. Rainer Kling
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100783	Electronic Circuits for Light Sources and Laser	3 CR	Kling

Prerequisites
none

M 6.61 Module: Electronics and EMC [M-ETIT-100410]

Responsible: Dr. Martin Sack
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	1	1

Mandatory			
T-ETIT-100723	Electronics and EMC	3 CR	Sack

Prerequisites
none

M 6.62 Module: Energy Storage and Network Integration [M-ETIT-101969]

Responsible: Prof. Dr.-Ing. Giovanni De Carne
apl. Prof. Dr. Francesco Grilli
Prof. Dr.-Ing. Mathias Noe

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-104644	Energy Storage and Network Integration	4 CR	Noe

Competence Certificate
Type of Examination: Oral exam

Duration of Examination: approx. 30 minutes

Prerequisites
Neither participation in "Energiespeicher und Netzintegration" (ETIT) nor in "Energiespeicher und Netzintegration" (MACH). Only one out of thesethree exams is allowed.

Competence Goal
Students understand the different types of energy storage and apply their knowledge for the selection and principal dimensioning of relevant energy storage tasks.

Furthermore, students can reflect the state-of-the-art of most important energy storage types, their fundamental characteristics and viability at given boundary conditions; they are enabled to elaborate and apply basic integration issues dependent on the grid structure for the different network types.

Practical work: The students are able to analyse real applications of energy storage and calculate basic design examples for the various storage options.

The students are able to discuss topic-related aspects in English using the technical terminology of the field of study.

Content
The lecture provides an overview of the different storage types and their fundamental integration into the power supply grid.

Thereby, within the scope of this lecture, the necessity and the motivation for converting and storing energy will be given. Starting from the definition of fundamental terms different physical and chemical storage types along with their theoretical and practical basis are described. In particular, the decoupling of energy production and energy consumption, and the provision of different energy scales (time, power, density) will be discussed. Furthermore, the challenge of energy transport and re-integration into the different grid types is considered.

1. Motivation for the need of energy storage in energy systems

a. National and international situation

b. Storage motivation

2. Terms and definitions

a. Different energy types

b. Definitions energy content

c. Definitions energy- and power density

3. Thermal energy storage

a. Classification

b. Sensitive heat storage

c. Latent heat storage

d. Reaction heat storage

4. Mechanical energy storage

a. Flywheels

b. Compressed air

c. Pumpes storage systems

5. Electrodynamic energy storage

a. Main principles

b. Capacitive and inductive storage

6. Electrochemical energy storage

a. Working principles

b. Batteries

c. Fuel Cells

7. Electric Power Systems

a. Storage tasks

b. Storage íntegration

c. Planning reserves

The obligatory **practical work** (23689) is related to real applications of energy storage and to basic design examples for the various storage options.

The lecturer reserves the right to alter the contents of the course without prior notification.

Course material will be available on ILIAS. The link to ILIAS and Up-to-date information will be available via the ITEP-homepage prior to the beginning of the semester (https://www.itep.kit.edu/148.php).

Module grade calculation
The module grade is the grade of the oral exam.

Annotation
Exam and Lecture will be held in English.

Workload
Approximately 120h workload of the student. The workload includes:

45h - attendance in lectures an exercises

45h - preparation / follow-up

30h - preparation of and attandance in examination

Recommendation
Basic knowledge in the fields of Electrical Engineering and Thermodynamics is helpful.

M 6.63 Module: Fabrication and Characterisation of Optoelectronic Devices [M-ETIT-101919]

Responsible: Prof. Dr. Bryce Sydney Richards
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-103613	Fabrication and Characterisation of Optoelectronic Devices	3 CR	Richards

Competence Certificate
Type of Examination: written exam

Duration of Examination: 120 Minutes

Modality of Exam: One written exam offered at the end of each semester.

Prerequisites
None

Competence Goal
The students build knowledge on process technology for the fabrication of a range of optoelectronic devices, including LEDs, solar cells, laser diodes, photodiodes, etc. They learn to compare the advantages of different technological approaches, including their economic boundary conditions. This is a technologiccal-based course where students will use their prior fundamental knowledge to gain a firm grasp on the fabrication sequences and characterisation (optical, electrical, electronic, materials) steps that are required to realise the above devices.

While fulfilling the learning targets, the students

- possess the basic knowledge about the working principles of optoelectronic devices;
- comprehend the boundary conditions for the design of optoelectronic devices and have a good understanding of the challenges in microfabrication
- are familiar with different lithographic techniques, including e-beam lithography, optical lithography, multiple-photon lithography, X-ray lithography, etc.
- comprehend the different techniques that are available for thin-film deposition of dielectrics, metals and semiconductors
- understand what role micro-optics can play in such devices
- be able to determine the most promising characterisation techniques for evaluating material quality, electronic properties, as well as optical and electrical performance.
- Exposure to different dry- and wet-etching processes to help realise device structures
- have an understanding of the economic implications of the chosen technologies and their compatibility with highthroughput production

Content

I. Overview: Opto-electronic Devices

II. Thin-film growth and deposition

- epitaxial growth of III-V semiconductors, as well as Si and Ge
- chemical vapour deposition (CVD) based processes, including atomic layer deposition (ALD)
- physical vapour deposition (PVD) based processes, including evaporation (thermal and e-beam) and sputtering (DC and RF)

III. Lithographic techniques

- e-beam lithography, optical lithography, laser interference lithography, two-photon lithography, X-ray lithography

IV. Etching processes

- wet- and dry-etching processes for semiconductors, dielectrics and metals

V. Micro-optics

- micro-optic design in opto-electronic devices

VI. Characterissation:

- materials properties (electron microscopy, crystallinity, bonding energies, elemeental concentrations, layer thicknesses ...)
- electronic properties (dopant profiling, mobility, minority carrier lifetimes, resistivity, bandgap measurements, ...)
- optical (spectrophotometry, photoluminescence, ...)
- electrical (current-voltage measurements, quantum efficiency / spectral response, ...)

VII. Excursion (TBA)

Module grade calculation

The module grade is the grade of the written exam.

Workload

Total 90h, hereof 30h contact hours (24h lecture,
6h problem class), and 60h homework and selfstudies

Literature

TBD

M 6.64 Module: Field Propagation and Coherence [M-ETIT-100566]

Responsible: Prof. Dr. Wolfgang Freude
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-100976	Field Propagation and Coherence	4 CR	Freude

Competence Certificate
Type of Examination: oral exam

Duration of Examination: approx. 30 minutes

Modality of Exam: Oral examination, usually one examination day per month during the summer and winter terms. An extra questions-andanswers session will be held for preparation if students wish so.

Prerequisites
none

Competence Goal
Presenting in a unified approach the common background of various problems and questions arising in general optics and optical comunications

The students

- knwo the common properties of counting of modes, density of states and the sampling theorem
- comprehend the relationship between propagation in multimode waveguides, mode coupling, MMI and speckles
- can analyze propagation in homogeneous media with respect to system theory, antennas, and the resolution limit of optical instruments
- understand that coherence as a general concept comprises coherence in time, in space and in polarisation
- comprehend the implication of complete spatial incoherence, and what is the radiation efficiency of a source with a diameter smaller than a wavelength (the mathematical Hertzian dipole, for instance)
- can assess when can two incandescent bulbs form an interference pattern in time
- know under which conditions a heterodyne radio receiver, which is based on a non-stationary interference, actually works

Content
The following selection of topics will be presented:

- Light waves, modes and rays: Longitudinal and transverse modes, sampling theorem, counting and density of modes ("states")
- Propagation in multimode waveguides. Near-field and far-field. Impulse response and transfer function. Perurations and mode coupling. Multimode interference (MMI) coupler. Modal noise (speckle)
- Propagation in homogeneous media: Resolution limit. Non-paracial and paracial optics. Gaussian beam. ABCD matrix
- Coherence of optical fields: Coherence function and power spectrum. Polarisation, eigenstates and principal states. Measurement of coherence with interferometers (Mach-Zehnder, Michelson). Self-heterodyne and self-homodyne setups

Module grade calculation
The module grade is the grade of the oral exam.

Workload
total 120 h, hereof 45 h contact hours (30 h lecture, 15 h problem class), and 75 h homework and self-studies

Recommendation
Minimal background required: Calculus, differential equations and Fourier transform theory. Electrodynamics and field calculations or a similar course on electrodynamics or optics is recommended.

Literature
Detailed lecture notes as well as the presentation slides can be downloaded from the IPQ lecture pages. Additional reading:

Born, M.; Wolf, E.: Principles of optics, 6. Aufl. Oxford: Pergamon Press 1980

Ghatak, A.: Optics, 3. Ed. New Delhi: Tata McGraw Hill 2005

Hecht, E.: Optics, 2. Ed. Reading: Addison-Wesley 1974

Hecht, J.: Understanding fiber optics, 4. Ed. Upper Saddle River: Prentice Hall 2002

Iizuka, K.: Elements of photonics, Vol. I and II. New York: John Wiley & Sons 2002

Further textbooks in German (also in electronic form) can be named on request

M 6.65 Module: Fundamentals on Plasma Technology [M-ETIT-100483]

Responsible: Dr.-Ing. Rainer Kling
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100770	Fundamentals on Plasma Technology	3 CR	Kling

Prerequisites
none

M 6.66 Module: Geodetic Space Techniques for Engineers (GuG_Export_GeodRaumvIng) [M-BGU-106347]

Responsible: Prof. Dr.-Ing. Hansjörg Kutterer
Dr. Kurt Seitz

Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-BGU-111169	Geodetic Space Techniques, Prerequisite *This item will not influence the grade calculation of this parent.*	1 CR	Kutterer, Seitz
T-BGU-112871	Geodetic Space Techniques for Engineers, Exam	3 CR	Kutterer

M 6.67 Module: Handling Characteristics of Motor Vehicles I [M-MACH-105288]

Responsible: Dr.-Ing. Martin Gießler
Dr.-Ing. Hans-Joachim Unrau

Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	2

Mandatory			
T-MACH-105152	Handling Characteristics of Motor Vehicles I	4 CR	Unrau

Competence Certificate
Oral examination, duration: approximately 30 minutes.

Competence Goal
The students know the basic connections between drivers, vehicles and environment. They can build up a vehicle simulation model, with which forces of inertia, aerodynamic forces and tyre forces as well as the appropriate moments are considered. They have proper knowledge in the area of tyre characteristics, since a special meaning comes to the tire behavior during driving dynamics simulation. Consequently they are ready to analyze the most importent influencing factors on the driving behaviour and to contribute to the optimization of the handling characteristics.

Content
1. Problem definition: Control loop driver - vehicle - environment (e.g. coordinate systems, modes of motion of the car body and the wheels)

2. Simulation models: Creation from motion equations (method according to D'Alembert, method according to Lagrange, programme packages for automatically producing of simulation equations), model for handling characteristics (task, motion equations)

3. Tyre behavior: Basics, dry, wet and winter-smooth roadway

Workload
The total work load for this module is about 120 Hours (4 Credits). The partition of the work load is carried out according to the credit points of the courses of the module. The work load for courses with 4 credit points is about 120 hours

Learning type
Lecture

6.68 Module: Hardware Modeling and Simulation [M-ETIT-100449]

Responsible: Dr.-Ing. Jens Becker
Prof. Dr.-Ing. Jürgen Becker

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-ETIT-100672	Hardware Modeling and Simulation	4 CR	Becker, Becker

Competence Certificate
Achievement is examined in the form of a written examination lasting 120 minutes.

Prerequisites
none

Competence Goal
After completing this module, students will be familiar with different hardware description languages and their applications in various abstraction levels. They will gain knowledge of the SPICE Hardware Description Language and become proficient in building and deriving the analog matrix for spice simulation. In the realm of digital design, they will develop a comprehensive understanding of the hardware description language VHDL, encompassing the VHDL Standard and its extensions, such as VHDL 2008, the 9-valued logic, and the VHDL-AMS standard. Furthermore, students will achieve a profound comprehension of simulator principles, particularly the delta cycle model. They will also grasp the fundamentals of fault simulations for testing fabricated circuits and learn to derive test vectors. Additionally, students will acquire an understanding of higher-level hardware construction languages like Chisel and SystemC.

Content
In order to address the complexity of modern chips during development, it is essential to utilize modern hardware description languages. This course offers insights into the various levels of abstraction in these languages. It starts by covering the fundamentals of analog description using SPICE and then progresses through VHDL, VHDL-AMS, and Verilog. Additionally, the course introduces more abstract languages like Chisel and SystemC.

Topics covered in the course are:

- Design Process
- Basics of Modeling and Simulation
- Low Level Modeling
- VHDL
  - VHDL-AMS
  - 9-valued logic
  - Delta cycle simulation
  - Fault simulation
- Verilog
- Chisel
- SystemC

Module grade calculation
The module grade results from the grade of the written examination.

Workload
The workload is covered by:

1. Participating in lectures and tutorials: 33h
2. Preparing and wrap up of the above named units: 66h
3. Exam preparation and presence: 21h

Sum: 120h = 4 LP

M 6.69 Module: Hardware Synthesis and Optimization [M-ETIT-106963]

Responsible: Prof. Dr.-Ing. Jürgen Becker
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Fundamentals)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-113922	Hardware Synthesis and Optimization	6 CR	Becker

Competence Certificate
The examination takes place within the framework of an oral overall examination (approx. 30 minutes)

Prerequisites
none

Competence Goal
Students know the basic steps required for the automated design of optimized digital circuits. They are able to classify them in the Y-chart and assess their complexity.

They will be able to name and explain the most important approaches for these design steps and evaluate them with regard to optimality and computational effort. This includes the ability to use algorithms for these approaches, e.g. selected graph algorithms, metaheuristics such as simulated annealing. The students are also able to determine their respective runtime complexities.

In addition, they can solve given problems from the field of design automation by selecting a suitable approach based on certain optimization criteria and applying it to the respective problem.

Content
The module focuses on teaching the formal and methodological foundations for the automated design of optimized electronic systems. The relevant scientific and methodological properties of the methods used are discussed and their implementation in industrial practice is also taught.

The following topics are covered:

- Graph Algorithms and Complexity
- High-Level Synthesis
- Algorithms for Scheduling, Allocation and Binding Problems
- Register-Transfer-Level Synthesis
- Retiming Algorithms
- Logic Optimization
- Technology Mapping for Standard Cells and FPGAs
- Physical Design
- Placement of Standard Cells with ILP and Simulated Annealing
- Global and Detailed Routing

Module grade calculation
The module grade is the grade of the oral exam.

Workload
The workload includes (4 SWS):

1. attendance in lectures and exercises: 50 h
2. preparation / follow-up: 50 h
3. preparation of and attendance in examination: 80 h

A total of 180 h = 6 CR

Recommendation
Basic knowledge in the field of digital circuits, e.g. as taught in the course “Digital Technology” (2311615) is helpful.

6.70 Module: Hardware/Software Co-Design [M-ETIT-100453]

Responsible: Prof. Dr.-Ing. Jürgen Becker

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Field of Specialization / Field of Specialization: Information and Communication Technology
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100671	Hardware/Software Co-Design	4 CR	Harbaum

Competence Certificate
Success control takes place in the form of an oral examination (approx. 20 minutes).

Prerequisites
none

Competence Goal
By attending the Hardware/Software Co-Design lecture, students learn the necessary multi-criteria methods and hardware/software target architectures. Attending the lecture contributes to the understanding of these methods of hardware/software co-design and enables students to apply what they have learned to novel problems.

Students learn about the main target architectures and are able to name their advantages and disadvantages with regard to their applicability in hardware/software co-design. Students will become familiar with various methods for assessing design quality and will be able to apply these in the early phases of system design. Furthermore, students have an overview of partitioning methods for HW/SW systems, can classify them and know the respective advantages and disadvantages of the methods. Students will be able to select and apply a suitable method for typical HW/SW partitioning problems.

By attending the course, students will have a cross-component understanding of the topic of co-design. Furthermore, attending the course enables students to apply the methods presented to problems independently. Tools that are introduced in the course of the lecture can be used for this purpose.

Attending the lecture enables students to independently classify current scientific work, e.g. theses, and to work on them using the latest methods.

Content

- The lecture presents the theoretical principles of the interlinked design of hardware and software parts of a system. In addition, their practical application is demonstrated using various current software and hardware components.
- The accompanying exercises are intended to consolidate the knowledge acquired in the lectures. Selected topics are repeated and students learn how to apply the methods for modern system design using theoretical and practical examples.
- Hardware-software co-design is the simultaneous and interlinked design of hardware and software parts of a system. Most modern embedded systems (examples are cell phones, automotive and industrial control systems, game consoles, home cinema systems, network routers) consist of cooperating hardware and software components. Enabled by rapid advances in microelectronics, embedded systems are becoming increasingly complex with diverse application-specific criteria. The use of appropriate computer-aided design tools is not only necessary to handle the increasing complexity, but also to reduce design costs and design time. The lecture Hardware Software Co-Design deals with the necessary multi-criteria methods and hardware/software target architectures:
    - Target architectures for hardware/software systems
        - Processor design: pipelining, superscalarity, VLIW, SIMD, cache, MIMD
        - General-purpose processors (GPP), microcontrollers (µC), digital signal processors (DSP), graphics processors (GPU), application-specific instruction set processors (ASIP), field programmable gate arrays (FPGA), system-on-chip (SoC), bus systems, multicore and network-on-chip (NoC)
    - Assessment of the design quality
        - Hardware and software performance
    - Hardware/software partitioning methods
        - Iterative and constructive heuristics

Module grade calculation
The module grade is the grade of the oral examination.

Annotation
Will be changed to 6 CR in winter term 25/26.

Workload
The workload includes:

1. attendance time in 14 lectures, 7 exercises: 31.5 hrs
2. preparation and follow-up of the same: 63 hours (3 hours per unit)
3. exam preparation and attendance: 20 hours preparation and 0.5 hours exam

Recommendation
Knowledge of the basics of digital technology and information technology is helpful.

M 6.71 Module: High-Power Microwave Technology [M-ETIT-100521]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100791	High-Power Microwave Technology	3 CR	Zwick

Competence Certificate
The success control is carried out as part of an oral overall examination (approx. 20 minutes) of the selected courses, which in total meet the minimum requirement for LP.

Prerequisites
none

Competence Goal
The students have a comprehensive overview of high-performance microwave technology, in particular the generation of high and very high power levels down to the THz range using modern vacuum electron tubes. They are able to describe different types and components of tubes, their mode of operation and their areas of application. The lecture includes transmission technology and diagnostics at high and highest performance, various applications in UHF transmission, in satellite communication, in radar technology, for THz applications (spectroscopy), in material process technology and in particle accelerator and fusion experiments. The students can identify the areas of application for the different tube types and assess their suitability.

Content
The term high-performance microwave technology means the generation, transmission, application and diagnostics of microwaves at high and very high outputs. In the lecture, the microwave range covers a frequency range from under 1 GHz (30 cm wavelength) to 1 THz (0.3 mm wavelength). The power range spans a range from 1 W (THz range) to over 1 MW in the classic microwave range (1 GHz to 300 GHz). The lecture focuses on microwave tubes as they are the only power generators and amplifiers that span such a frequency and power range. The lecture thus fulfills the requirements of modern satellite communication, THz spectroscopy, radar technology, particle accelerators and fusion. The applications mentioned have a rapidly increasing need for ever more powerful high-performance microwave components.

The lecture is interdisciplinary. This introduces the dominant tube types and deals with the associated components. The preferred fields of application for the respective tube types are explained. Components for high-performance transmission and diagnostics are presented.

Module grade calculation
The module grade is the grade of the oral exam.

Annotation
Will be changed to English in winter term 25/26.

Workload
The workload includes:

Attendance study time lecture / exercise: 30 h

Self-study time including exam preparation: 60 h

A total of 90 h = 3 LP

Recommendation
Knowledge of the basics of high frequency technology is helpful.

M 6.72 Module: High-Voltage Technology [M-ETIT-105060]

Responsible: Dr.-Ing. Rainer Badent
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-110266	High-Voltage Technology	6 CR	Badent

M 6.73 Module: High-Voltage Test Technique [M-ETIT-100417]

Responsible: Dr.-Ing. Rainer Badent
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-101915	High-Voltage Test Technique	4 CR	Badent

Prerequisites
none

M 6.74 Module: Human Brain and Central Nervous System: Anatomy, Information Transfer, Signal Processing, Neurophysiology and Therapy (24139 / 24678) [M-INFO-100725]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each term	1 term	German	4	1

Mandatory			
T-INFO-101262	Human Brain and Central Nervous System: Anatomy, Information Transfer, Signal Processing, Neurophysiology and Therapy	3 CR	Asfour, Spetzger

M 6.75 Module: Image Processing [M-ETIT-102651]

Responsible: Prof. Dr.-Ing. Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-105566	Image Processing	3 CR	Heizmann

Competence Certificate
Success control takes place in the form of a written examination lasting 120 minutes.

Prerequisites
none

Competence Goal

- Students have a sound knowledge of the fundamentals and procedures of machine vision and automatic visual inspection
- Students are proficient in different methods for image acquisition, pre-processing and image evaluation and can characterize them based on their prerequisites, model assumptions and results.
- Students are able to analyse and structure machine vision and automatic visual inspection tasks, synthesize possible solutions from image processing methods and assess their suitability.

Content
Machine vision is a collective term for the acquisition of image signals using optical imaging and cameras, the processing of the recorded image signals using (digital) image signal processing and the evaluation of the image data to obtain useful information from the recorded images.

The module teaches the basics, procedures and exemplary applications of machine vision.

The contents include in detail

- Optical imaging
    - Imaging with pinhole camera, central projection
    - Imaging with lens (objective)
- Color
    - Photometry
    - Color perception and color spaces
    - Filters
- Sensors for image acquisition
    - CCD, CMOS sensors
    - Color sensors
    - Quality criteria
- Image recording methods
    - Recording of optical properties
    - Capturing the spatial shape (3D shape)
- Image signals
    - Mathematical description of image signals
    - System theory
    - Fourier transform
- Preprocessing and image enhancement
    - Simple image enhancement measures
    - Reduction of systematic interference
    - Reduction of random interference
- Segmentation
    - Area-oriented segmentation
    - Edge-oriented methods
- Texture analysis
    - Texture types
    - Model-based texture analysis
    - Feature-based texture analysis
- Detection
    - Detection of known objects using linear filters
    - Detection of unknown objects (defects)
    - Straight line detection (Radon and Hough transformation)

Module grade calculation
The module grade is the grade of the written examination.

Workload
The preparation (0.5 h), the attendance (1.5 h) and the follow-up (1 h) of the weekly lecture as well as the preparation (45 h) and participation (2 h) in the exam result in a total workload of approx. 90 h.

Recommendation
Knowledge of the contents of the modules "Signale und Systeme" (e.g. Fourier transformation, sampling) and "Measurement Technology" (e.g. noise, matched filters) is an advantage.

6.76 Module: Industrial Circuitry [M-ETIT-100399]

Responsible: Dr.-Ing. Andreas Liske
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100716	Industrial Circuitry	3 CR	Liske

Prerequisites
none

Module grade calculation
Die Modulnote ist die Note der mündlichen Prüfung.

6.77 Module: Information Fusion [M-ETIT-103264]

Responsible: Prof. Dr.-Ing. Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-106499	Information Fusion	4 CR	Heizmann

Prerequisites
none

M 6.78 Module: Information Technology in Industrial Automation Systems [M-ETIT-100367]

Responsible: Dr.-Ing. Peter-Axel Bort
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100698	Information Technology in Industrial Automation Systems	3 CR	Bort

Prerequisites
none

M 6.79 Module: Integrated Intelligent Sensors [M-ETIT-100457]

Responsible: Prof. Dr. Wilhelm Stork
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100961	Integrated Intelligent Sensors	3 CR	Stork

Competence Certificate
Achievement will be examined in an oral examination (approx. 20 minutes).

Prerequisites
none

M 6.80 Module: Integrated Systems and Circuits [M-ETIT-100474]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100972	Integrated Systems and Circuits	4 CR	Kempf

Prerequisites
none

6.81 Module: Interfaculty Team Project [M-ETIT-103076]

Responsible: Dr.-Ing. Rainer Kling
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-106110	Interfaculty Team Project	6 CR	Kling

Prerequisites
none

6.82 Module: Introduction into Energy Economics [M-WIWI-100498]

Responsible: Prof. Dr. Wolf Fichtner
Organisation: KIT Department of Economics and Management
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each summer term	1 term	German	4	4

Mandatory			
T-WIWI-102746	Introduction to Energy Economics	5,5 CR	Fichtner

Competence Certificate
The assessment consists of a written exam according to Section 4(2), 1 of the examination regulation.

Prerequisites
None

Competence Goal
The student is able to

- characterize and judge the different energy carriers and their peculiarities,
- understand contexts related to energy economics.

Content
1. Introduction: terms, units, conversions
2. The energy carrier gas (reserves, resources, technologies)
3. The energy carrier oil (reserves, resources, technologies)
4. The energy carrier hard coal (reserves, resources, technologies)
5. The energy carrier lignite (reserves, resources, technologies)
6. The energy carrier uranium (reserves, resources, technologies)
7. The final carrier source electricity
8. The final carrier source heat
9. Other final energy carriers (cooling energy, hydrogen, compressed air)

Workload
The total workload for this course is approximately 165.0 hours. For further information see German version.

6.83 Module: Introduction to Automotive and Industrial Lidar Technology [M-ETIT-105461]

Responsible: Prof. Dr. Wilhelm Stork
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-111011	Introduction to Automotive and Industrial Lidar Technology	3 CR	Stork

Competence Certificate
The examination consists of an oral exam and a short oral presentation. The overall impression is rated.

Competence Goal

- The students are able to explain the basic principles of a lidar sensor
- The students can explain all relevant components of a lidar sensor and put them in context
- The students can explain different forms of execution and make a meaningful choice depending on the requirements
- The students can describe lidar sensors theoretically using the lidar equations and explain the interactions based on this theory
- The students are able to assess the eye safety of a system
- The students are able to suggest possible sensor concepts for different applications or to evaluate existing concepts

Content
In this course the functionality of a lidar sensor is explained and then put into context with relevant use cases. Typical criteria for the evaluation of the performance are then presented. In the following the concept of the sensor is presented in detail and all relevant components are introduced individually. Afterwards they are qualitatively related to each other and the whole system is quantitatively examined by means of the lidar equation. Finally, the interaction of the components is further considered to present meaningful combinations and design solutions. The eye safety of lidar sensors is always explicitly considered. The course concludes with a colloquium in which the students will give short presentations on what they have learned. This repetition is intended to repeat and deepen what has been learned and to lead to a discussion of open question

Module grade calculation
The module grade results of the assessment of the oral exam and the short oral presentation. Details will be given during the lecture.

Workload

1. participation in the lectures 12h - 8 dates á 1,5h
2. preparation and postprocessing 14 h (2h for VL dates 1-7)
3. preparation of the short lecture (16h)
4. preparation and participation in the oral exam : 48h

Recommendation
Basics of optics / optical technologies are helpful (e.g. optical engineering, optoelectronic, technical optics)

M 6.84 Module: Introduction to Microsystem Technology I [M-MACH-102691]

Responsible: Prof. Dr. Jan Gerrit Korvink
Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-MACH-105182	Introduction to Microsystem Technology I	4 CR	Badilita, Jouda, Korvink

Competence Certificate
Written exam: 60 min

Prerequisites
None

Competence Goal
The lecture gives an introduction into the basics of microsystems technology. In analogy to processes employed in fabrication of microelectronics circuits the core technologies as well as materials for producing microstructures and components are presented. Finally, various techniques for Silicon micromachining are explained and illustrated with examples for micro-components and micro-systems.

Content
- Introduction in Nano- and Microtechnologies
- Silicon and processes for fabricating microelectronics circuits
- Basic physics background and crystal structure
- Materials for micromachining
- Processing technologies for microfabrication
- Silicon micromachining
- Examples

Workload
Time of attendance: 15 * 1,5 h = 22,5 h

Preparation and follow up: 15 * 5,5 h = 82,5 h

Exam Preaparation and Exam: 15 h

Total: 120 h = 4 LP

Literature
M. Madou
Fundamentals of Microfabrication
Taylor & Francis Ltd.; Auflage: 3. Auflage. 2011

M 6.85 Module: Introduction to Video Analysis (24684) [M-INFO-100736]

Responsible: Prof. Dr.-Ing. Jürgen Beyerer
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-INFO-101273	Introduction to Video Analysis	3 CR	Beyerer

M 6.86 Module: IT/OT-Security Seminar [M-ETIT-106789]

Responsible: Prof. Dr.-Ing. Mike Barth
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-113648	IT/OT-Security Seminar	4 CR	Barth

Competence Certificate
The examination takes place in the form of an oral examination.

Prerequisites
none

Competence Goal
The students:
- know the definitions of terms and use-cases in the IT/OT-Security Domain
- know security requirements of both: the industrial information technology perspecitiv as well as the production related operational technology domain
- can apply basic cryptographic mechanisms with focus on industrial IT networks
- know protection goals of IT/OT-security
- know various aspects of system security (buffer overflow, return-oriented programming, ...)
- can differentiate between classic information technology (IT) and operational technology (OT) in an industrial environment
- are familiar with attacks on industrial automation and control systems (Industrial Control Systems - ICS)
- are familiar with various concepts (defense-in-depth, security by design, ...) and specific security mechanisms (Public-Key-Infrastucture, network segmentation, ...) of OT security
- are familiar with current international security standards for ICS, in particular IEC 62443
- know the different roles involved and their challenges in the life cycle of ICS
- know and understand the concept of a risk analysis for security
- can evaluate the quality of security mechanisms and architectures for industrial systems
- know typical industrial communication protocols and can analyze and evaluate their security mechanisms

Content
- Industrial control and automation systems (ICS) are widely used in numerous domains and industries. They play a crucial role in areas such as industrial production, the process industry, critical infrastructures such as energy and water management, building automation and medical devices.
- In recent years, the frequency of vulnerabilities and attacks on these systems has increased, especially since the emergence of Stuxnet in 2014. As a result, the protection of ICS has become increasingly important.
- Compared to conventional IT systems, ICS have different boundary conditions and requirements. In particular, the focus is on availability and maintaining functional safety. Therefore, classic approaches to information security cannot be applied to industrial control systems without adaptation.
- This module first provides basic knowledge of security. Building on this, concepts, mechanisms and standards for the specific domain of ICS are introduced. This includes, for example:

o Defense-in-Depth concepts
o Risk-based approaches
o IEC 62443
o Structure and operation of cyber security management systems
o Security engineering
o Use of security information and event management systems in the industrial environment
o Secure use of Industry 4.0 technologies such as OPC UA

Module grade calculation
The module grade is the grade of the oral exam.

Workload
The workload includes:

1. attendance in seminar lectures and exercises: 12*2 h = 24 h
2. preparation / follow-up of seminar lectures: 12*3 h = 36 h
3. implementation of challenges and exercises: 12*3 h = 36 h
4. preparation of exam: 24 h.

A total of 120 h = 4 CR

Recommendation
Enjoy working with networked software systems in the production and industrial IT environment. Curiosity in the interplay between attackers and defenders as well as a general affinity to software related topics.

M 6.87 Module: Lab Course Electrical Drives and Power Electronics [M-ETIT-100401]

Responsible: Prof. Dr. Martin Doppelbauer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100718	Lab Course Electrical Drives and Power Electronics	6 CR	Doppelbauer

Prerequisites
none

6.88 Module: Lab Course Electrical Power Engineering [M-ETIT-100419]

Responsible: Prof. Dr. Martin Doppelbauer
Prof. Dr.-Ing. Thomas Leibfried

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100728	Lab Course Electrical Power Engineering	6 CR	Badent, Doppelbauer, Leibfried

Prerequisites
none

M 6.89 Module: Lab Course on Nanoelectronics [M-ETIT-100468]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each term	1 term	German/English	4	1

Mandatory			
T-ETIT-100757	Lab Course on Nanoelectronics	6 CR	Kempf

Competence Certificate
The control of success takes place in form of the evaluation of a written report (approx. 10-20 pages) which introduces the topic, discusses the execution of the lab course and the scientific results puts the results into the overall context.

Prerequisites
none

Competence Goal
After successful completion of the module, students will be familiar with elementary processes of microsystems and thin-film technology and will be able to optimize the fabrication of thin-film structures independently and without external guidance. In addition, they will be able analyze and critically evaluate their results using adequate measuring tools. By working on the practical course in small groups, students also acquire or improve their teamwork skills.

Content
The students learn the basic procedures and processes for the fabrication of integrated circuits as they are also used in industry. After an introduction, they work on specified tasks in the clean room and technology laboratory of the Institute for Micro- and Nanoelectronic Systems and work independently on a set of tasks agreed upon in advance with the supervisor. In detail, the students learn the following methods or processes:

- Fabrication of thin films and multilayer systems by sputtering and thermal vapor deposition.
- Fotolithography
- Characterization of the manufactured devices at room temperature and low temperatures.
- Independent analyses, measurements and evaluations of characteristic quantities of the fabricated structures such as critical temperature, residual resistance ratio, current-voltage characteristics, etc.

The results are subsequently summarized by the students in a final report, put into context and critically discussed.

Module grade calculation
The module grade is the grade of the written report.

Annotation
Two weeks block course in lecture-free time

Workload
A workload of approx. 180h is required for the successful completion of the module. This is composed as follows:

- Preparation of the lab course: 20h
- Discussion and lab course planning with supervisor: 10h
- Attendance time in the lab course: 70h
- Preparation of the written report: 80h

Recommendation
Successful completion of the module M-ETIT-103451 - Thin Films: technology, physics and application I or M-ETIT-105608 - Physics, Technology and Applications of Thin Films is recommended.

M 6.90 Module: Lab Course on Noise Thermometry [M-ETIT-106263]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each term	1 term	German/English	4	1

Mandatory			
T-ETIT-112714	Lab Course on Noise Thermometry	6 CR	Kempf

Competence Certificate
The examination takes place in form of other types of examination. This consists of oral questions and a report on the contents and results of each of the three independent parts of the internship. The overall impression is evaluated.

Prerequisites
none

Competence Goal
After successful completion of the module, students will know the basics of noise thermometry as well as how modern, SQUID based noise thermometers can be built and operated. They will particularly know how to interpret measured temperature values and critically evaluate the noise budget. By working on the practical course in small groups, the students will also acquire or improve their teamwork skills.

Content
Noise thermometry is a proven method for primary thermometry and is therefore intensively used and further developed in many metrology institutes. The principle of this method is based on the measurement of the voltage or current noise of an electrical resistor. Within the scope of this practical course, the students will gain a detailed insight into noise thermometry. In the first part, they will design a transistor or operational amplifier-based circuit for measuring the thermal noise of a high-impedance resistor at room temperature. Using this circuit, the students will then measure the thermal noise of some resistors to verify the Nyquist theorem, Based on this, the students will design a noise thermometer for the temperature range between 4 K and 10 K in the second part of the lab course. It will be based on a superconducting quantum interference device (SQUID). With the help of this highly sensitive current sensor, the students will measure the thermal noise of a low-resistance resistor at different temperatures below 10 K and thus practically experience the basic principle of noise thermometry. Finally, in the last part of the practical course, the students will become familiar with the construction of a commercial noise thermometer in the range from 100 mK to 4 K with this noise thermometer. All three parts of the experiment will be accompanied by explanations and discussions of the underlying physical principles, the special features of the circuit design, etc. The students will also have the opportunity to learn more about the cryostats.

Module grade calculation
The oral discussion as well as the protocols of the three experimental parts are included in the evaluation of the examination performance of another kind. Details will be given during the lecture.

Workload
A workload of approx. 180 h is required for the successful completion of the module. This is composed as follows:

1. Preparation of the lab course: 40 h
2. Discussion and lab course planning with supervisor: 10 h
3. Attendance time in the lab course: 70 h
4. Preparation of the written report: 60 h

Recommendation
The contents of the module “Quantum Detectors and Sensors” or “Nano- and Quantum Electronics” might be helpful.

M 6.91 Module: Lab Course on Superconducting Quantum Electronics [M-ETIT-105605]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each term	1 term	German/English	4	1

Mandatory			
T-ETIT-111233	Lab Course on Superconducting Quantum Electronics	6 CR	Kempf

Competence Certificate
The control of success takes place in form of the evaluation of a written report (approx. 10-20 pages) which introduces the topic, discusses the execution of the lab course and the scientific results puts the results into the overall context.

Prerequisites
none

Competence Goal
After successful completion of the module, students will know how elementary components of quantum electronics work and will be able to design, build and characterize quantum electronic circuits independently and without external guidance using these components. They know how to interpret measured parameters and characteristics and how to relate them to circuit properties. Furthermore, the students understand elementary aspects of the characterization of quantum electronic circuits at low temperatures and have an insight into the required interconnection technology as well as the realization of specific applications using quantum electronic circuits. By working on the practical course in small groups, students also acquire or improve their teamwork skills.

Content
Today, superconducting quantum electronics plays an important role in many areas of research, society and industry. For example, quantum computers have been shown to outperform classical computers, and diagnostic systems based on superconducting quantum interference detectors in the field of medical technology have become an indispensable part of everyday clinical practice.

Against this background, students will learn the basic operation of elementary components of superconducting quantum electronics (Josephson junctions, SQUID, superconducting wiring, etc.) and how to design, build and characterize quantum electronic circuits independently and without external guidance using these components. In fact, students characterize Josephson tunnel junctions, superconducting quantum interference detectors or superconducting microwave resonators in consultation with the supervisor and build circuits for a specific application using these elements. For example, a quasi-primary thermometer for low temperatures or an nA current sensor can be realized. Students characterize the circuits they build and compare the results to the design parameters. In this environment, students also gain a brief insight into the methods of low-temperature engineering, which plays an essential role in the field of superconducting quantum electronics.

Module grade calculation
The module grade is the grade of the written report.

Workload
A workload of approx. 180h is required for the successful completion of the module. This is composed as follows:

- Preparation of the lab course: 20h
- Discussion and lab course planning with supervisor: 10h
- Attendance time in the lab course: 70h

Preparation of the written report: 80h

Recommendation
Successful completion of the modules "Quantum detectors and sensors" and "Nano- and quantum electronics" is recommended.

M 6.92 Module: Lab Course Printed Flexible Electronics [M-ETIT-106464]

Responsible: Prof. Dr. Gerardo Hernandez Sosa
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	pass/fail	Each term	1 term	English	4	2

Mandatory			
T-ETIT-113075	Lab Course Printed Flexible Electronics	6 CR	Hernandez Sosa

Competence Certificate
The examination consists of a written journal article and an oral presentation of the student's work, both given in English. The overall impression is rated.

Prerequisites
The M-ETIT-100475 Modul: Plastic Electronics / Polymerelektronik should be started.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-ETIT-100475 - Plastic Electronics / Polymerelectronics must have been started.

Competence Goal
The students will gain practical experience in the use of measuring instruments and manufacturing processes for printed electronics technology and the methods for determining the physical and optical properties of the fabricated components. They will be able to fabricate devices such as photodetectors and thin film transistors, and electrically characterize them. Furthermore, they will evaluate measurement results and correlate the fabrication process conditions to the device characteristics. They will be able to critically evaluate their results using adequate measurement tools. In addition, they will have the competence to report the results in written form and to interpret the knowledge gained from the experiments. By working on the practical course in small groups, students also acquire or improve their teamwork skills.

Content
This module is designed to teach students the theoretical and practical aspects of laboratory work in the field of Printed and Flexible Electronics by means of guided and independently conducted practical experiments. In the four experiments, the student will learn to handle real measurement and fabrication technology on the scientific equipment of the institute such as various printers, probe stations, characterization methods and formulation of inks. The module also teaches the competence to write a scientific report, as well as the rules to visualize data sets in a meaningful way.

The working titles of the experiments are:

1) Ink formulation and characterization of Functional Inks

2) Printing optimization of an Inkjet Printer for functional Electronics

3) Fabrication and characterization of a printed sensor device.

Fabrication of a printed thin film transistor device with subsequent electrical characterization

Module grade calculation
The module is passed with successful assessment of the written paper and the oral presentation. Details will be given during the lecture. The module is ungraded.

Annotation
- The lab is limited to a number of 6 participants due to capacity reasons. If necessary, a selection procedure will be carried out. Places will be allocated taking into account the students' academic progress. Details will be announced on the lecture website.

- The Lab course will take place in the clean room Facilities of InnovationLab in Heidelberg. Speyerer str. 4, 69115 Heidelberg where the research laboratories of Prof. Hernandez-Sosa are located.

- The 4 th experiment will take place at KIT Campus North, Institute of Nanotechnology, in the research unit and laboratories of Prof. Jasmin Aghassi-Hagmann.

Attendance of at least 80% is compulsory during the seminar course. Compulsory attendance is necessary for actively contributing to the discussion of the topics presented by all students.

Workload
Due to the self-administration of the groups (max. 3 students):

1 x 5 hours are required for organizational tasks. This includes the attendance of the information event, the attendance of 2 safety briefings (general safety and clean room) as well as the organizational tasks for the individual appointment between the experiment supervisor and the small group.

For the 4 experiments in the module, the workload is calculated as follows:

4 x 5 h familiarization with the topic and literature study on the basics incl. preparation for the entrance examination.

4 x 8 h presence for the execution of experiments at the institute

4 x 1 h discussion of results and learned concepts

4 x 10 h data preparation and visualization

4 x 15 h writing of an individual report on the basis of the measured data and the research question.

4 x 1 h final discussion on the experiment with feedback on the report

4 x 4 h Rework of the report on the basis of the feedback on the report.

Total hours = 181 h = 6 LP

Recommendation
Basic knowledge in the field of conventional and/or organic (opto) electronic or printed devices and sensors is helpful. The course Modern VLSI is recommended but not necessary.

6.93 Module: Laboratory Biomedical Engineering [M-ETIT-100389]

Responsible: Prof. Dr. Werner Nahm
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	2

Mandatory			
T-ETIT-101934	Laboratory Biomedical Engineering	6 CR	Nahm

Prerequisites
Passed exam of the module "Biomedizinische Messtechnik I".

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-ETIT-100387 - Biomedical Measurement Techniques I must have been passed.

M 6.94 Module: Laboratory Circuit Design [M-ETIT-100518]

Responsible: Prof. Dr.-Ing. Jürgen Becker
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives (Usage until 9/30/2025)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	2

Mandatory			
T-ETIT-100788	Laboratory Circuit Design	6 CR	Becker, Sander

Prerequisites
none

Competence Goal
The practical course teaches necessary knowledge and abilities to design electric circuits as used to interface microcontrollers/ FPGAs with sensors and actors. At the end of this course the participants are capable of selecting electronic components based on relevant criteria, combining them to basic building blocks, and setting up a working system for a given problem. In addition to circuit design, basic methods and abilities for the creation of PCB layouts are taught. Finally, the participants are enabled to assemble and test their designed circuits in real setups.

Content
This course is a three-week practical block event. Its goal is the development and setup of the complete electronics used to run a self-balancing single-axis transportation device.

The first part of the course covers commonly used electric circuits which are presented in interactive lecture style. This covers circuits for voltage supply, clock generation, sensor signal pre-processing, power drivers, and display control, among others. Real-world components are presented based on their datasheets. To consolidate this knowledge, the lecture is interwoven with small practical exercises where students set up and experiment with the presented circuits. This first part aims at refreshing basic knowledge from previous courses as well as imparting knowledge on often-used basic circuits.

After presenting the basic circuits there is a short presentation on PCB layout design. This part comprises an introduction of the PCB layout tool used in the course, followed by tips on placement and wiring of components on the PCB. It covers the topics of noise and crosstalk reduction, placement of bypass capacitors, and ground design.

During the third and longest part of the course, the participants work in teams to create a concept, schematics, and layouts of circuit parts to run the transportation device. Requirements are given concerning the functionality of the circuit parts as well as interfaces to neighboring parts only. All further development steps are carried out by the students themselves, based on the knowledge from the first two parts of the course.

Workload
The workload includes

1. presence in the laboratory: 15 days of 8h each = 120h
2. course preparation/recapitulation: 15 days of 2h each = 30h
3. exam preparation and attendance: 15h

Recommendation
Basic knowledge on basic electrical circuits (e.g. courses LEN, Nr. 2305256, ES, Nr. 2312655 and EMS, Nr. 2306387)

M 6.95 Module: Laboratory FPGA Based Circuit Design [M-ETIT-100470]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each term	1 term	German	4	1

Mandatory			
T-ETIT-100759	Laboratory FPGA Based Circuit Design	6 CR	Kempf

Prerequisites
none

M 6.96 Module: Laboratory in Software Engineering [M-ETIT-100460]

Responsible: Prof. Dr.-Ing. Eric Sax
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100681	Laboratory in Software Engineering	6 CR	Sax

Prerequisites
none

M 6.97 Module: Laboratory Information Systems in Power Engineering [M-ETIT-100415]

Responsible: Prof. Dr.-Ing. Thomas Leibfried
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100727	Laboratory Information Systems in Power Engineering	6 CR	Leibfried

Prerequisites
none

M 6.98 Module: Laboratory Lighting Technology [M-ETIT-102356]

Responsible: Prof. Dr. Cornelius Neumann
Dr.-Ing. Klaus Trampert

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each term	1 term	German/English	4	1

Mandatory			
T-ETIT-104726	Laboratory Lighting Technology	6 CR	Neumann

Competence Certificate
Success is assessed on the basis of a total of four experiments. The overall impression is graded.

Prerequisites
none

Competence Goal
Students have practical experience in using photometric measurement equipment and methods for determining the photometric and electrical properties of lamps and luminaires. They also have basic experience in the simulation of luminaires with CAE tools.

They will be able to assess the plausibility of measurement results and estimate the influence of the measurement method on the uncertainty of the result.

They also have the competence to summarise the results in written form and to interpret the knowledge gained from the measurements scientifically and to explain the physical and photometric properties of lamps and luminaires.

Content
This module is designed to teach students the theoretical and practical aspects of laboratory work in the field of lighting technology by means of independently performed practical experiments. In the four experiments, the handling of real measurement technology is trained on the institute's scientific equipment. The module also teaches the skills required to write a scientific report and the rules for the appropriate visualisation of data sets.

The working titles of the experiments are:

1. thermal spectral behaviour of LEDs
2. far-field goniophotometry
3. near-field goniophotometry
4. simulation of optical systems

Module grade calculation
Oral examinations and the assessment of written assignments are included in the module grade. Further details will be provided at the beginning of the course.

Workload
Due to the self-administration of the small groups:

1 x 5 h are required for organizational tasks. This includes attending the information event, attending 2 safety briefings (laser and clean room) and making individual appointments between the experiment supervisor and the small group.

The workload for the 4 experiments in the module is calculated as follows:

4 x 5 h familiarization with the topic and literature study on the basics including preparation for the admission test.

4 x 8 h attendance at the institute

4 x 10 h data preparation and visualization

4 x 16 h Writing an individual report on the basis of the measurement data and the research question for the experiment.

4 x 1 h final discussion on the experiment with feedback on the report

4 x 4 h Improvement of the report based on the feedback on the report

Total hours required = 181 h = 6 CR

Recommendation

Knowledge of the theoretical principles of the individual experiments is helpful. It is highly recommended to attend the module after attending the lectures relevant to the subject, as knowledge of the theoretical basics is helpful but not mandatory. If the basics from the corresponding modules are not present, a longer preparation time for the respective experiment is needed.

Helpful modules: Light technology, optoelectronic measurement technology, photometry and radiometry

M 6.99 Module: Laboratory Mechatronic Measurement Systems [M-ETIT-103448]

Responsible: Prof. Dr.-Ing. Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-106854	Laboratory Mechatronic Measurement Systems	6 CR	Heizmann

Competence Certificate
The success control is carried out in the form of a written test of 120 minutes. If there are fewer than 20 candidates, an oral exam of around 20 minutes can alternatively take place. The module grade is the grade of the written or oral exam.

Prerequisites
none

Competence Goal

- Students have in-depth knowledge of different methods for measuring objects, especially surfaces.
- Students master different procedures for the metrological recording of objects and know the relevant requirements, procedures and results.
- Students are able to implement procedures for evaluating sensor data from (surface) measuring devices and to evaluate the quality of the measurement result.

Content
A large number of different measuring methods and systems can be used for the quality inspection of technically manufactured objects and their surfaces. Examples are white light interferometry, confocal microscopy and systems based on focus variation. The measurement methods and systems naturally differ in terms of the physical measurement principle used, but also in terms of the evaluation of the raw sensor data recorded.

In this internship, different systems for the metrological recording of (technical) surfaces are presented and their properties are characterized. In the test dates, the students themselves create procedures and algorithms for processing the sensor data in order to obtain information about the desired geometric and / or optical properties of the examined surface. The algorithms obtained are evaluated on the basis of sensor data from exemplary objects and characterized in terms of the quality of the measurement statements achieved.

Module grade calculation
The module grade is the grade of the written or oral exam.

Annotation
The submission of the protocols of all experiments is required for admission to the examination. The quality of the protocols is assessed; for the admission to the exam, the quality must be acceptable. Attendance of all laboratory dates including the introductory event is required. Already in the event of a single unexcused absence, admission to the examination will not be granted.

Workload
Total: approx. 160 hours, of which

1. Attendance time in introductory session: 1.5 hours
2. Preparation of the test dates: 32 h
3. Attendance time in test appointments (8 appointments of 4 hours each): 32 hours
4. Follow-up of the test dates, Creation of the minutes: 32 h
5. Exam preparation and attendance in the same: 60 h

Recommendation
Knowledge from the lectures "Metrology" or "Metrology in Mechatronics" and "Manufacturing Metrology" as well as basic knowledge of programming (e.g. in Matlab, C / C ++) are helpful.

M 6.100 Module: Laboratory Mechatronics [M-MACH-102699]

Responsible: Prof. Dr. Veit Hagenmeyer
Prof. Dr.-Ing. Wolfgang Seemann
Prof. Dr.-Ing. Christoph Stiller

Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	pass/fail	Each winter term	1 term	German	4	2

Mandatory			
T-MACH-105370	Laboratory Mechatronics	4 CR	Hagenmeyer, Stiller

Competence Certificate
The laboratory course is offered exclusively as ungraded course work. The assessment consists of a group colloquium at the beginning of the individual specialization phases (Part 1). In addition, a robot control system for a pick-and-place task must be successfully implemented in the group phase (Part 2).

Prerequisites
None

Competence Goal
The students are able to put the knowledge from the specialization in mechatronics and microsystems technology into practice on an exemplary mechatronic system, a handling system. The students can create an automated object recognition, calculate kinematic systems and realize a communication between different systems (PC, CAN, USB).

Furthermore, the students can integrate the individual parts of a manipulator in teamwork to a functioning overall system.

Content
Part I
Control, programming and simulation of robots
CAN-Bus communication
Image processing / machine vision
Dynamic simulation of robots in ADAMS

Part II
In a group work, a kinematic system has to be programmed so that it is able to recognize and grip objects fully automatically.

Module grade calculation
The module is not graded. Passing the module is 100% tied to the performance assessment of the partial performance.

Workload

1. Attendance time Lecture: 15 * 2 h = 30h
2. self-study: 15 * 6 h = 90h

Total: 120h = 4 LP

Learning type
Seminar

6.101 Module: Laboratory Modern Software Tools in Power Engineering [M-ETIT-105402]

Responsible: Prof. Dr.-Ing. Thomas Leibfried
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-110898	Laboratory Modern Software Tools in Power Engineering	6 CR	Leibfried

Competence Certificate
The control of success is carried out in the form of a total of 3 grades of the experiments (1 grade per experiment) in accordance with § 4 Paragraph 2 No. 3 SPO-Master2015-016, 2018

Prerequisites
none

Competence Goal
Students have a basic understanding of how to use common calculation programs from the domain of grid calculation, field calculation and EMT calculation in energy systems. They are able to perform basic calculations in the respective sub-areas and are familiar with the underlying theory.

Content
The main focus of the lecture is to teach profound knowledge in the domain of field calculation using the finite element method, load flow and short circuit calculation as well as the design of controllers in EMT simulations. The theoretical basics of the sub-areas will be taught and the practical application with the help of common programs will be practiced by means of case studies.

Module grade calculation
Scoring results from the subscores of the experiments.

Annotation
For capacity reasons, the laboratory is limited to a number of 5 students. If necessary, a selection procedure will be carried out. Places will be allocated taking into account the study progress of the applicants.

Workload
Time of attendance: 40 hours

Self study time: 140 hours

Total 180 hours = 6 credits

Recommendation
Basic knowledge from the lectures High Voltage Engineering, Calculation of Electrical Grids and Electric Power Transmission and Grid Control. PC knowledge and English skills.

M 6.102 Module: Laboratory Nanotechnology [M-ETIT-100478]

Responsible: Prof. Dr. Ulrich Lemmer
Dr.-Ing. Klaus Trampert

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Lab Course)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each term	1 term	German/English	4	1

Mandatory			
T-ETIT-100765	Laboratory Nanotechnology	6 CR	Lemmer

Competence Certificate
Success control takes place in the form of a total of four tests. The overall impression is rated.

Prerequisites
none

Competence Goal
The students have practical experience in the use of measuring devices and manufacturing processes in nanotechnology and the methods for determining the physical and optical properties of optoelectronic components with functional nanotechnology components.

They can evaluate measurement results with regard to their plausibility and assess the influence of the measurement method on the uncertainty of the result.

You will also be able to reproduce the results in written form and interpret the knowledge gained from the measurements scientifically and explain the physical properties and the influence of the nanotechnology components.

Content
This module is designed to teach students the theoretical and practical aspects of laboratory work in the field of nanotechnology by means of independently conducted practical experiments. In the four experiments, students practise working with real measurement technology using the scientific equipment of the institute. The module also teaches students how to write a scientific report and the rules for the meaningful visualization of data sets.

The working titles of the experiments are

1. Production and characterization of an OLED
2. Optical mask lithography
3. Fabrication and characterization of an electrochromic device
4. Nanoimprint lithography and scanning electron microscopy

Module grade calculation
Oral examinations and the assessment of written assignments are included in the module grade. Further details will be provided at the beginning of the course.

Workload
Due to the self-administration of the small groups:

1 x 5 h are required for organizational tasks. This includes attending the information event, attending 2 safety briefings (laser and clean room) and making individual appointments between the experiment supervisor and the small group.

The workload for the 4 experiments in the module is calculated as follows:

4 x 5 h familiarization with the topic and literature study on the basics including preparation for the admission test.

4 x 8 h attendance at the institute

4 x 10 h data preparation and visualization

4 x 16 h Writing an individual report on the basis of the measurement data and the research question for the experiment.

4 x 1 h final discussion on the experiment with feedback on the report

4 x 4 h Improvement of the report based on the feedback on the report

Total hours required = 181 h = 6 CR

Recommendation
Knowledge of the theoretical principles of the individual experiments is helpful. It is advisable to attend the module after attending the subject-relevant courses, as knowledge of the theoretical basics is helpful but not mandatory. If the basics from the corresponding modules are not available, this means a longer preparation time for the respective experiment.

Helpful modules: Solid state electronics

M 6.103 Module: Laboratory Optoelectronics [M-ETIT-100477]

Responsible: Dr.-Ing. Klaus Trampert
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each term	1 term	German/English	4	1

Mandatory			
T-ETIT-100764	Laboratory Optoelectronics	6 CR	Trampert

Competence Certificate
Success control takes place in the form of a total of four tests. The overall impression is rated.

Prerequisites
none

Competence Goal
Students have practical experience in using optoelectronic measuring devices and methods for determining the photometric and electrical properties of light sources and their operating devices.

They will be able to assess the plausibility of measurement results and estimate the influence of the measurement method on the uncertainty of the results.

You will also be able to reproduce the results in written form and interpret the knowledge gained from the measurements scientifically and use this to explain the physical properties of the light sources or the control gear.

Content
This module is designed to teach students the theoretical and practical aspects of laboratory work in the field of optoelectronics by means of independently conducted practical experiments. In the four experiments, students practise using real measurement technology on the scientific equipment of the institute. The module also teaches students how to write a scientific report and the rules for the meaningful visualization of data sets.

The working titles of the experiments are

1. Operating behavior of fluorescent lamps
2. Spectrophotometer | spectral transmission and reflection
3. Characterization of organic lasers
4. Spectroscopy & photosensor technology.

Module grade calculation
Oral examinations and the assessment of written assignments are included in the module grade. Further details will be provided at the beginning of the course.

Workload
Due to the self-administration of the small groups:

1 x 5 h are required for organizational tasks. This includes attending the information event, attending 2 safety briefings (laser and clean room) and making individual appointments between the experiment supervisor and the small group.

The workload for the 4 experiments in the module is calculated as follows:

4 x 5 h familiarization with the topic and literature study on the basics including preparation for the admission test.

4 x 8 h attendance at the institute

4 x 10 h data preparation and visualization

4 x 16 h Writing an individual report on the basis of the measurement data and the research question for the experiment.

4 x 1 h final discussion on the experiment with feedback on the report

4 x 4 h Improvement of the report based on the feedback on the report

Total hours required = 181 h = 6 CR

Recommendation
Knowledge of the theoretical principles of the individual experiments is helpful. It is advisable to attend the module after attending the subject-relevant courses, as knowledge of the theoretical basics is helpful but not mandatory. If the basics from the corresponding modules are not available, this means a longer preparation time for the respective experiment.

Helpful modules: Solid-state electronics, optoelectronic measurement technology, plasma radiation sources

M 6.104 Module: Laboratory Solar Energy [M-ETIT-102350]

Responsible: Prof. Dr. Ulrich Wilhelm Paetzold
Prof. Dr. Bryce Sydney Richards
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each term	1 term	German/English	4	1

Mandatory			
T-ETIT-104686	Laboratory Solar Energy	6 CR	Trampert

Competence Certificate
Success is assessed on the basis of a total of four experiments. The overall impression is graded.

Prerequisites
none

Competence Goal
Students have practical experience in using photometric measurement equipment and methods for determining the photometric and electrical properties of lamps and luminaires. They also have basic experience in the simulation of luminaires with CAE tools.

They will be able to assess the plausibility of measurement results and estimate the influence of the measurement method on the uncertainty of the result.

They also have the competence to summarise the results in written form and to interpret the knowledge gained from the measurements scientifically and to explain the physical and photometric properties of lamps and luminaires.

Content
This module is designed to teach students the theoretical and practical aspects of laboratory work in the field of solar technology, particularly in the field of photovoltaics, by means of independently conducted practical experiments. In the four experiments, the handling of real measurement technology is trained on the institute's scientific equipment. The module also teaches the skills required to write a scientific report and the rules for the appropriate visualisation of data sets.

The working titles of the experiments are:

1. Light Beam Induced Current (LBIC) measurement in solar cells
2. Optical and electrical modelling of thin-film solar cells
3. Quantum efficiency measurements on solar cells
4. Outdoor measurements of PV modules

Module grade calculation
Oral examinations and the assessment of written reports are included in the module grade. Further details will be provided at the beginning of the course.

Workload
Due to the self-administration of the small groups:

1 x 5 h are required for organizational tasks. This includes attending the information event, attending 2 safety briefings (laser and clean room) and making individual appointments between the experiment supervisor and the small group.

The workload for the 4 experiments in the module is calculated as follows:

4 x 5 h familiarization with the topic and literature study on the basics including preparation for the admission test.

4 x 8 h attendance at the institute

4 x 10 h data preparation and visualization

4 x 16 h Writing an individual report on the basis of the measurement data and the research question for the experiment.

4 x 1 h final discussion on the experiment with feedback on the report

4 x 4 h Improvement of the report based on the feedback on the report

Total hours required = 181 h = 6 CR

Recommendation
Knowledge of the theoretical background of each experiment is recommended. It is strongly recommended that you attend this module after attending the relevant lectures, as knowledge of the theoretical background is important but not strictly necessary.

M 6.105 Module: Laser Metrology [M-ETIT-100434]

Responsible: Prof. Dr. Marc Eichhorn
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-100643	Laser Metrology	3 CR	Eichhorn

Competence Certificate
The exam will be taken as an oral examination (about 20 minutes). The individual appointments for examination are offered regularly at two previously determined dates.

Prerequisites
none

Competence Goal
The students understand the fundamental properties of laser light and possess the knowledge necessary to understand the metrologically obtainable information, understand the basics of various detectors as well as their limits and have the knowledge necessary to understand a multitude of laser metrological setups, mainly for interferometry, Moiré methods, distance and velocity measurements and absorption as well as scattering techniques.

Content
In the module several aspects of laser diagnostics will be discussed, beginning with the fundamental properties of laser light and the related metrologically useful information. In addition beam diagnostics and interferometric setups in general, as well as Moiré methods in particular, will be discussed. Further topics of the lecture will be commonly used setups, mainly for laser distance and velocity measurements along with widely used absorption and scattered light methods.

1. Laser diagnostics - theoretical considerations (laser beam properties, coherence, spectral emission of lasers, mode structure and selection, coherence length)
2. Metrological accessible information (propagation in homogeneous and isotropic, in inhomogeneous and in anisotropic media)
3. Beam diagnostics (photoelectric detectors, information theory, granulation properties of laser light)
4. Laser-Interferometer (fundamentals, two-beam Interferometer, interferometry applications in plasma physics, two- and multiwavelength-interferometry, laser gyroscopes)
5. Moiré technique (Moiré deflectometry, Fresnel- and Fraunhofer diffraction, applications and evaluation of the Moiré technique)
6. Laser range measurements (fundamentals, atmospheric influence on propagation, optical distance measurement techniques, accuracy, sensitivity, heterodyne detection, selected heterodyne detection schemes, tomoscopy)
7. Laser velocity measurement techniques (Doppler principle, measuring flow velocities using Doppler effect, the two-focus technique or laser anemometry; time-resolved imaging particle-trace anemometry)
8. Absorption and scattering techniques (absorption techniques, LIDARs, scattering processes in laser diagnostics, spontaneous scattering techniques, spectroscopic techniques, stimulated scattering, nonlinear optical laser light scattering techniques)

Module grade calculation
The module grade is the grade of the oral exam.

Workload
About 90 h in total, consisting of

30 h lectures

60 h recapitulation and self-studies

Literature
M. Eichhorn, *Laser metrology* - Scriptum

A. E. Siegman, *Lasers* (university Science Books)

B. E. A. Saleh, M. C. Teich, *Fundamentals of Photonics* (Wiley-Interscience)

M 6.106 Module: Laser Physics [M-ETIT-100435]

Responsible: Prof. Dr. Marc Eichhorn
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-100741	Laser Physics	4 CR	Eichhorn

Competence Certificate
The exam will be taken as an oral examination (about 20 minutes). The individual appointments for examination are offered at two previously determined dates.

Prerequisites
none

Competence Goal
The students understand the fundamental relations and basics of a laser. They obtain the knowledge necessary for understanding and designing lasers (laser media, optical resonators, pumping schemes) and understand the basics and schemes for pulse generation in a laser. They have the knowledge needed for a multitude of lasers: gas, solid-state, fiber and disc lasers from the visible up to the mid-Infrared spectrum.

Content
Within the module the physical basics of lasers, the fundamental processes of light amplification and the formalisms necessary to describe lasers and laser resonators are covered. The generation of laser pulses and various laser architectures as well as realisations are presented in detail.

The exercises specifically discuss the topics of laser description, theoretical background as well as the realization of different laser designs. The tasks of the exercise will be handed out at the end of each lecture as well as uploaded to the lecture website and are to be solved for the following exercise, in which the solution will be discussed.

Contents:

1 Quantum-mechanical fundamentals of lasers

1.1 Einstein relations and Planck´s law

1.2 Transition probabilities and matrix elements

1.3 Mode structure of space and the origin of spontaneous emission

1.4 Cross sections and broadening of spectral lines

2 The laser principles

2.1 Population in version and feedback

2.2 Spectroscopic laser rate equations

2.3 Potential model of the laser

3 Optical Resonators

3.1 Linear resonators and stability criterion

3.2 Mode structure and intensity distribution

3.3 Line width of the laser emission

4 Generation of short and ultra-short pulses

4.1 Basics of Q-switching

4.2 Basics of mode locking and ultra-short pulses

5 Laser examples and their applications

5.1 Gas lasers: The Helium-Neon-Laser

5.2 Solid-state lasers

5.2.1 The Nd3+-Laser

5.2.2 The Tm3+-Laser

5.2.3 The Ti3+:Al2O3 Laser

5.3 Special realisations of lasers

5.3.1 Thermal lensing and thermal stress

5.3.2 The fiber laser

5.3.3 The thin-dis laser

Module grade calculation
The module grade is the grade of the oral exam.

Workload
About 120 h in total, consisting of

30 h lectures

15 h tutorial

75 h recapitulation and self-studies

Literature
M. Eichhorn, Laser physics (Springer)
M. Eichhorn, Laserphysik (Springer)
A. E. Siegman, Lasers (University Science Books)
B. E. A. Saleh, M. C. Teich,Fundamentals of Photonics (Wiley-Interscience)
F. K. Kneubühl, M. W. Sigrist, Laser (Teubner)

6.107 Module: Liberalised Power Markets [M-WIWI-105403]

Responsible: Prof. Dr. Wolf Fichtner
Organisation: KIT Department of Economics and Management
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-WIWI-107043	Liberalised Power Markets	5,5 CR	Fichtner

Competence Certificate
Success is monitored in the form of a written examination.

Prerequisites
See course description.

Competence Goal
The student has extensive knowledge of the new requirements of liberalized energy markets.

Content

1. Power markets in the past, now and in future

2. Designing liberalised power markets

2.1. Unbundling Dimensions of liberalised power markets

2.2. Central dispatch versus markets without central dispatch

2.3. The short-term market model

2.4. The long-term market model

2.5. Market flaws and market failure

2.6. Regulation in liberalised markets

3. The power (sub)markets

3.1 Day-ahead market

3.2 Intraday market

3.3 (Long-term) Forwards and futures markets

3.4 Emission rights market

3.5 Market for ancillary services

3.6 The “market” for renewable energies

3.7 Future market segments

4. Grid operation and congestion management

4.1. Grid operation

4.2. Congestion management

5. Market power

5.1. Defining market power

5.2. Indicators of market power

5.3. Reducing market power

6. Future market structures in the electricity value chain

1. Power markets in the past, now and in future

2. Designing liberalised power markets

2.2. Unbundling Dimensions of liberalised power markets

2.3. Central dispatch versus markets without central dispatch

2.4. The short-term market model

2.5. The long-term market model

2.6. Market flaws and market failure

2.7. Regulation in liberalised markets

3. The power (sub)markets

3.1 Day-ahead market

3.2 Intraday market

3.3 (Long-term) Forwards and futures markets

3.4 Emission rights market

3.5 Market for ancillary services

3.6 The “market” for renewable energies

3.7 Future market segments

4. Grid operation and congestion management

4.1. Grid operation

4.2. Congestion management

5. Market power

5.1. Defining market power

5.2. Indicators of market power

5.3. Reducing market power

6. Future market structures in the electricity value chain

Workload

The total workload for this module is approximately 180 hours.

M 6.108 Module: Light and Display Engineering [M-ETIT-100512]

Responsible: Dr.-Ing. Rainer Kling
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-100644	Light and Display Engineering	4 CR	Kling

Competence Certificate
Type of Examination: Oral exam

Duration of Examination: approx. 25 minutes

Modality of Exam: The oral exam is flexibly held by student request after the WS.

Prerequisites
none

Competence Goal
The students will apply their comprehensive knowledge of physics of optical phenomena to applied optical systems in light and display engineering. These applications span from human sensing with the eye to light technologies with lamps, luminaires and displays. The course gives a broad overview how optics can be applied in modern technology fields. The subjects taught are further clarified by demonstrations, models and experiments.

The students

- can derive the description of basic of light engineering starting from the eye and the visual system
- know how to handle basic metrical units and know how to measure them
- understand the visible sensing in contrast to radiation measurements
- comprehend the concepts of colour and colour control
- are familiar with all types of light sources from low pressure lamps to LED modules
- conceive the operation principle of various types of drivers
- know how to set up a luminaire and how simulate a reflector
- they understand how active (Plasma Displays) and passive displays (TFT Display) work and how to operate them
- have a good visualization of numerous optical design approaches

Content

1. Motivation: Light & Display Engineering
2. Light, the Eye and the Visual System (including Melatonin)
3. Fundamentals in Light Engineering
4. Light in non - visual Processes (UV Processes)
5. Color and Brightness
6. Light Sources (Halogen, Low Pressure and High Pressure Lamps, LED Engines) and electronic Drivers
7. Displays (Active and Passive Displays: AMOLED, E-ink, TFT Display, Plasma Display)
8. Luminaries (Fundamentals, Design Rules, Simulations)
9. Optical Design (Ray tracing, Reflector design, Computed Ray tracing)

Module grade calculation
The module grade is the grade of the oral exam.

Workload
total 120 h, hereof 45 h contact hours (lecture and tutorial), and 75 h homework and self-studies

Recommendation
Basic physics background

Literature

Simons, Lighting Engineering: Applied Calculations, 2001

Shunsuke Kobayashi: LCD Backlights, 2009

Winchip, Fundamentals of Lighting, 2nd Edition, 2011

Malacara, Handbook of Optical Design, 2004

M 6.109 Module: Lighting Design - Theory and Applications [M-ETIT-100577]

Responsible: Dr.-Ing. Rainer Kling
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-100997	Lighting Design - Theory and Applications	3 CR	Kling

Competence Certificate
Type of Examination: Oral exam

Duration of Examination: approx. 25 minutes

Modality of Exam: The oral exam is flexibly held by student request after the WS.

Prerequisites
none

Competence Goal
The students will apply a comprehensive knowledge of Lighting Design from theory, standards and applications in Indoor and Outdoor lighting. Examples and own Lighting design examples as projects. So a practical and theoretical background is applied to Lighting Design. From metrics too Light Planning projects in small exercise groups. The subjects taught are further clarified by demonstrations, models and experiments. Attending students get the knowledge to Lighting Design, in a shorter theoretical part and practical lighting design simulations with examples from all over the world.

The students

- can derive the description of basics of Lighting Design
- know how to handle basic metrical units and know how to measure them
- understand the Lighting Design metrics to apply on projects
- have a good visualization of numerous design approaches
- realize good Lighting Design with codes and standards.
- can see energy savings levels for Lighting Design
- comprehend the lighting design by practical self-computing lessons:
- can realize own indoor Lighting design concepts for different applications like Office, School, Shops, Gyms & Industry
- can realize own outdoor Lighting Design concepts for Street lighting, Tunnels, Stade and Parkings
- can use for realization Relux and Dialux light planning software so set up Project Planning for Lighting Design.

Content
1. Lighting Design - Introduction form all over the world

2. Lighting Fundamentals

3. Lighting Design Theory

4. Energy Savings and Lighting design

5. Lighting Design Tools

6. Computing Standards

7. Lighting Design Applications (Practical Part)

7.1 Interior Lighting

7.2 Exterior lighting

7.3 IlluminationOwn Calculation Examples (Practical Part)Motivation: Light & Display Engineering

8. Own Calculation Examples (Practical Part)Motivation: Light & Display Engineering

Module grade calculation
The module grade is the grade of the oral exam.

Workload
total 90 h, hereof 45 h contact hours (Seminar), and 45 h homework and self-studies

Recommendation
Hearing first M-ETIT-100512 - Light and Display Engineering lecture is beneficial.

Literature

J. Livingstone: Designing With Light: The Art, Science and Practice of Architectural Lighting Design, 2014

S. Russel: The Architecture Of Light: Interior Designer and Lighting Designer, 2012

M. Karlen: Lighting Design Basics, Indoor Lightin, 2004

R.H. Simons Lighting Engineering, 2001Simons, Lighting Engineering: Applied Calculations, 2001

R. Winchip, Fundamentals of Lighting, 2nd Edition, 2011

M 6.110 Module: Lighting Engineering [M-ETIT-100485]

Responsible: Prof. Dr. Cornelius Neumann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100772	Lighting Engineering	4 CR	Neumann

Prerequisites
none

M 6.111 Module: Localization of Mobile Agents (24613) [M-INFO-100840]

Responsible: Prof. Dr.-Ing. Uwe Hanebeck
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-INFO-101377	Localization of Mobile Agents	6 CR	Hanebeck

M 6.112 Module: Low Power Design (24672) [M-INFO-100807]

Responsible: Prof. Dr.-Ing. Jörg Henkel
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German/English	4	1

Mandatory			
T-INFO-101344	Low Power Design	3 CR	Henkel

Competence Certificate
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
Students learn how to take energy-saving measures into account for all levels of embedded system design while maintaining computing power. After completing the lecture, the student will be able to analyse the recognise problematic energy consumption recognise problematic energy consumption and take measures to eliminate it.

Content
Nowadays, power consumption is the most important criterion when designing on-chip systems. While other design criteria such as performance used to be decisive, it is now essential to optimise for power consumption as this is the limiting factor. In fact, power consumption has changed a lot in the last decade: the fact that there are now multi-core chips instead of single-core chips is a direct consequence of power consumption. Power consumption is by no means just a question of hardware, but is also decisively determined by the software and the operating system. The lecture is therefore indispensable for all those who deal with on-chip systems at hardware, software and operating system level.
The lecture therefore provides an overview of design methods, synthesis methods,
estimation methods, software techniques, operating system strategies, scheduling methods, etc., with the aim of minimising the power consumption of on-chip systems of embedded systems while maintaining the required performance. Both research-relevant and already established (i.e. implemented in products) techniques at different levels of abstraction (from circuit to system) are covered in the lecture.

Workload
90 h
Lecture 1.5h: 12 x 1.5 = 18hPreparation per lecture 2h: 12x2 = 24h
Preparation for exam 7 days: 7x8 = 56h
Total: 98h

M 6.113 Module: Machine Learning 1 [M-WIWI-105003]

Responsible: Prof. Dr.-Ing. Johann Marius Zöllner
Organisation: KIT Department of Economics and Management
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-WIWI-106340	Machine Learning 1 - Basic Methods	5 CR	Zöllner

Competence Certificate
The assessment of this course is a written examination (60 min) according to §4(2), 1 of the examination regulation or an oral exam (20 min) following §4, Abs. 2, 2 of the examination regulation.

The exam takes place every semester and can be repeated at every regular examination date.

Prerequisites
None

Competence Goal

- Students gain knowledge of the basic methods in the field of machine learning.
- Students understand advanced concepts of machine learning and their application.
- Students can classify, formally describe and evaluate methods of machine learning.
- Students can use their knowledge to select suitable models and methods for selected problems in the field of machine learning.

Content
The course prepares students for the rapidly evolving field of machine learning by providing a solid foundation, covering core concepts and techniques to get started in the field. Students delve into different methods in supervised, unsupervised, and reinforcement learning, as well as various model types, ranging from basic linear classifiers to more complex methods, such as deep neural networks. Topics include general learning theory, support vector machines, decision trees, neural network fundamentals, convolutional neural networks, recurrent neural networks, unsupervised learning, reinforcement learning, and Bayesian learning.

The course is accompanied by a corresponding exercise, where students gain hands-on experience by implementing and experimenting with different machine learning algorithms, helping them to apply machine learning algorithms on real world problems.

By the end of the course, students will have acquired a solid foundation in machine learning, enabling them to apply state-of-the-art algorithms to solve complex problems, contribute to research efforts, and explore advanced topics in the field.

Workload
The total workload for this module is approximately 150 hours.

Literature
Further reading

- Machine Learning - Tom Mitchell
- Deep Learning - Ian Goodfellow, Yoshua Bengio, Aaron Courville
- Pattern Recognition and Machine Learning - Christopher M. Bishop
- Artificial Intelligence: A Modern Approach - Peter Norvig and Stuart J. Russell
- Reinforcement Learning: An Introduction - Richard S. Sutton and Andrew G. Barto

Further (specific) literature on individual topics will be given in the lecture.

M 6.114 Module: Machine Learning 2 [M-WIWI-105006]

Responsible: Prof. Dr.-Ing. Johann Marius Zöllner
Organisation: KIT Department of Economics and Management
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-WIWI-106341	Machine Learning 2 – Advanced Methods	5 CR	Zöllner

Competence Certificate
The assessment of this course is a written examination (60 min) according to §4(2), 1 of the examination regulation or an oral exam (20 min) following §4, Abs. 2, 2 of the examination regulation.

The exam takes place every semester and can be repeated at every regular examination date.

Prerequisites
None

Competence Goal

- Students gain knowledge of the basic methods in the field of machine learning.
- Students understand advanced concepts of machine learning and their application.
- Students can classify, formally describe and evaluate methods of machine learning.
- Students can use their knowledge to select suitable models and methods for selected problems in the field of machine learning.

Content
The subject area of machine intelligence and, in particular, machine learning, taking into account real challenges of complex application domains, is a rapidly expanding field of knowledge and the subject of numerous research and development projects.

The lecture "Machine Learning 2" deals with modern advanced methods of machine learning such as semi-supervised and active learning, deep neural networks (deep learning, CNNs, GANs, diffusion models, transformer, adversarial attacks) and hierarchical approaches, e.g. reinforcement learning. Another focus is the embedding and application of machine learning methods in real systems.

The lecture introduces the latest basic principles as well as extended basic structures and elucidates previously developed algorithms. The structure and the mode of operation of the methods and methods are presented and explained by means of some application scenarios, especially in the field of technical (sub) autonomous systems (vehicles, robotics, neurorobotics, image processing, etc.).

Workload
The total workload for this module is approximately 150 hours.

Literature

- Deep Learning - Ian Goodfellow
- Artificial Intelligence: A Modern Approach - Peter Norvig and Stuart J. Russell
- Machine Learning - Tom Mitchell
- Pattern Recognition and Machine Learning - Christopher M. Bishop
- Reinforcement Learning: An Introduction - Richard S. Sutton and Andrew G. Barto
- Deep Learning - Ian Goodfellow, Yoshua Bengio, Aaron Courville

M 6.115 Module: Machine Learning and Optimization in Communications [M-ETIT-104988]

Responsible: Prof. Dr.-Ing. Laurent Schmalen
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	4

Mandatory			
T-ETIT-110123	Machine Learning and Optimization in Communications	4 CR	Schmalen

Competence Certificate
Written examination of 120 minutes.

Prerequisites
Knowledge of basic engineering mathematics probability theory as well as basic knowledge of communications engineering (e.g. "M-ETIT-102103 – Nachrichtentechnik I" and "M-ETIT-102104 – Wahrscheinlichkeitstheorie").

Competence Goal
The students will be able to apply the methods and tools of machine learning, artificial intelligence and optimization in communications engineering. You will learn various tools and solution methods of machine learning, artificial intelligence and numerical optimization, and you can use these tools to solve telecommunications problems.

Content
The course broadens the questions dealt with in the lecture Communication Engineering I. The focus here is on methods that arise when considering communication networks. For this purpose, partially known techniques have to be extended, in some cases new methods have to be learned. The first part of the lecture deals with modern methods of machine learning, e.g. deep neural networks, and uses examples to show how they are used in communication networks. The second part of the lecture considers numerical optimization methods and their application to telecommunication questions. In the exercise concrete questions from practice are considered and solved together with the students. The focus of the problems lies in the field of communications engineering. Many of the applications are illustrated with example implementations in software (python).

Module grade calculation
The module grade is the grade of the written examination.

A bonus can be earned by successfully participating in the tutorial session. The exact criteria for awarding a bonus will be announced at the beginning ft he lecture period. If the grade in the exam is between 4.0 and 1.3, the bonus improves the grade by one grade (0.3 or 0.4). Bonus points do not expire and are retained for any examinations taken at a later date. The final assessment ft he bonus performance is carried out by the examiner and demonstrably documented.

Workload
- Lecture attendance: 15 * 2 h = 30 h

- Presence time exercise: 15 * 1 h = 15 h
- Lecture preparation/-revision phase: 15 * 2 h = 30 h

- Exercise preparation/-revision phase: 15 * 1 h = 15 h
- Exam preparation and attendance: 30 h

Total workload: approx. 120 h

Recommendation
Knowledge from the modules "M-ETIT-100444 – Angewandte Informationstheorie" and "M-ETIT-105982 – Measurement Technology" is helpful.

M 6.116 Module: Machine Learning and Optimization in Energy Systems [M-WIWI-106604]

Responsible: Prof. Dr. Wolf Fichtner
Organisation: KIT Department of Economics and Management
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-WIWI-113073	Machine Learning and Optimization in Energy Systems	4 CR	Fichtner

Competence Certificate
The assessment of this module is a written examination (60 min) or an oral exam (30 min) depending on the number of participants.

Prerequisites
None.

Competence Goal
Participants know about the most common optimization and machine learning approaches for the application in energy systems. They understand the basic principles of the methods and are able to apply them for solving important problems of future energy systems with high shares of renewable energy sources.

Content
In the beginning, the essential transition of the energy system into a smart grid and the need for methods from the field of optimization and machine learning are explained. The course can be subdivided into an optimization part and a larger machine learning part. In the optimization part, the basics of optimization approaches that are used in energy systems are shown. Further, heuristic methods and approaches from the field of multiobjective optimization are introduced. In the machine learning part, the most important methods from the field of unsupervised learning, supervised learning and reinforcement learning are introduced and their application in future energy systems are investigated.

Amongst the considered applications are power plant dispatch, intelligent heating with heat pumps, charging strategies for electric vehicles, clustering of energy data for energy system models and electricity demand and renewable generation forecasting.

We also offer a voluntary computer exercise that deepens the understanding of the methods and applications covered in the lecture. The students will have the opportunity to solve problems from the energy domain by using optimization and machine learning approaches implemented in the programming language Python.

The course's general focus is on the application of the methods in the energy field and not on the mathematical details of the different approaches.

Module grade calculation
The module grade is the grade of the written or oral exam.

Workload
The total workload for this module is approximately 120 hours:

- Attendance: 30 hours
- Self-study: 45 hours
- Exam preparation: 55 hours

M 6.117 Module: Machine Tools and Industrial Handling (WW4INGMB32) [M-MACH-101286]

Responsible: Prof. Dr.-Ing. Jürgen Fleischer
Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
9	Grade to a tenth	Each winter term	1 term	German	4	5

Mandatory			
T-MACH-110963	Machine Tools and High-Precision Manufacturing Systems	9 CR	Fleischer

Competence Certificate
Oral exam (45 minutes)

Prerequisites
None

Competence Goal
The students

- are able to assess the use and application of machine tools and high-precision manufacturing systems and to differentiate between them in terms of their characteristics and design.
- can describe and discuss the essential elements of machine tools and high-precision manufacturing systems (frame, main spindle, feed axes, peripheral equipment, control unit).
- are able to select and dimension the essential components of machine tools and high-precision manufacturing systems.
- are capable of selecting and evaluating machine tools and high-precision manufacturing systems according to technical and economic criteria.

Content
The module gives an overview of the construction, use and application of machine tools and high-precision manufacturing systems. In the course of the module a well-founded and practice-oriented knowledge for the selection, design and evaluation of machine tools and high-precision manufacturing systems is conveyed. First, the main components of the systems are systematically explained and their design principles as well as the integral system design are discussed. Subsequently, the use and application of machine tools and high-precision manufacturing systems will be demonstrated using typical machine examples. Based on examples from current research and industrial applications, the latest developments are discussed, especially concerning the implementation of Industry 4.0 and artificial intelligence.
Guest lectures from industry round off the module with insights into practice.

The individual topics are:

- Structural components of dynamic manufacturing Systems
- Feed axes: High-precision positioning
- Spindles of cutting machine Tools
- Peripheral Equipment
- Machine control unit
- Metrological Evaluation
- Maintenance strategies and condition Monitoring
- Process Monitoring
- Development process for machine tools and high-precision manufacturing Systems
- Machine examples

Workload
regular attendance: 63 hours
self-study: 207 hours

Learning type
Lecture, exercise, excursio

M 6.118 Module: Machine Vision (Sp-MV) [M-MACH-101923]

Responsible: Dr. Martin Lauer
Prof. Dr.-Ing. Christoph Stiller

Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-MACH-105223	Machine Vision	8 CR	Lauer, Stiller

Competence Certificate
Type of Examination: written exam
Duration of Examination: 60 minutes

Prerequisites
None

Competence Goal
After having participated in th lecture the participants have gained knowledge on modern techniques of machine vision and pattern recognition which can be used to evaluatecamera images. This especially includes techniques in the areas of gray level image analysis, analysis of color images, segementation of images, describing the geometrical relationship between the image and the 3-dimensional world, and pattern recognition with various classification techniques. The participants have learned to analyze the algorithms mathematically, to implement them in software, and to apply them to tasks in video analysis. The participants are able to analyze real-world problems and to develop appropriate solutions.

Content

The lecture on machine vision covers basic techniques of machine vision. It focuses on the following topics:

image preprocessing

edge and corner detection

curve and parameter fitting

color processing

image segmentation

camera optics

pattern recognition

deep learning

Image preprocessing:

The chapter on image processing discusses techniques and algorithms to filter and enhance the image quality. Starting from an analysis of the typical phenomena of digital camera based image capturing the lecture introduces the Fourier transform and the Shannon-Nyquist sampling theorem. Furthermore, it introduces gray level histogram based techniques including high dynamic range imaging. The disussion of image convolution and typical filters for image enhancement concludes the chapter.

Edge and corner detection:

Gray level edges and gray level corners play an important role in machine vision since gray level edges often reveal valueable information about the boundaries and shape of objects. Gray level corners can be used as feature points since they can be identified easily in other images. This chapter introduces filters and algorithms to reveal gray level edges and gray level corners like the Canny edge detector and the Harris corner detector.

Curve and parameter fitting:

In order to describe an image by means of geometric primitives (e.g. lines, circles, ellipses) instead of just pixels robust curve and parameter fitting algorithms are necessary. The lecture introduces and discusses the Hough transform, total least sum of squares parameter fitting as well as robust alternatives (M-estimators, least trimmed sum of squares, RANSAC)

Color processing:

The short chapter on color processing discusses the role of color information in machine vision and introduces various models for color understanding and color representation. It concludes with the topic of color consistency.

Image Segmentation:

Image segmentation belongs to the core techniques of machine vision. The goal of image segmentation is to subdivide the image into several areas. Each area shares common properties, i.e. similar color, similar hatching, or similar semantic interpretation. Various ideas for image segmentation exist which can be used to create more or less complex algorithms. The lecture introduces the most important approaches ranging from the simpler algorithms like region growing, connected components labeling, and morphological operations up to highly flexible and powerful methods like level set approaches and random fields.

Camera optics:

The content of an image is related by the optics of the camera to the 3-dimensional world. In this chapter the lecture introduces optical models that describe the relationship between the world and the image including the pinhole camera model, the thin lens model, telecentric cameras, and catadioptric sensors. Furthermore, the lecture introduces camera calibration methods that can be used to determine the optical mapping of a real camera.

Pattern recognition:

Pattern recognition aims at recognizing semantic information in an image, i.e. not just analyzing gray values or colors of pixels but revealing which kind of object is shown by the pixels. This task goes beyond classical measurement theory and enters the large field of artificial intelligence. Rather than just being developped and optimized by a programmer, the algorithms are adapting themselves to their specific task using training algorithms that are based on large collections of sample images.

The chapter of pattern recognition introduces standard techniques of pattern recognition in the context of image understanding like the support vector machine (SVM), decision trees, ensemble and boosting techniques. It combines those classifiers with powerful feature representation techniques like the histogram of oriented gradients (HOG) features, locally binary patterns (LBP), and Haar features.

Deep learning:

Throughout recent years standard pattern recognition technqiues have more and more been outperformed by deep learning techniques. Deep learning is based on artificial neural networks, a very generic and powerful form of a classifier. The lecture introduces multi layer perceptrons as the most relevant form of artificial neural networks, discusses training algorithms and strategies to achieve powerful classifiers based on deep learning including deep auto encoders, convolutional networks, and multi task learning, among others.

Workload

240 hours, omposed out of

hours of lecture: 15*4 h = 60 h

preparation time prior to and after lecture: 15*6 h = 90 h

exam preparation and exam: 90 h

Learning type
Lecture

Literature
Main results are summarized in the slides that are made available as pdf-files. Further recommendations will be presented in the lecture.

M 6.119 Module: Measurement Technology [M-ETIT-105982]

Responsible: Prof. Dr.-Ing. Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-112147	Measurement Technology	5 CR	Heizmann

Competence Certificate
The examination takes place in form of a written examination lasting 120 minutes.

Prerequisites
M-ETIT-102652 - Messtechnik (German version) must not have started.

Competence Goal

- Students have a sound knowledge of the theoretical foundations of measurement technology, including modeling of measurement systems, consideration of nonlinearities, stochastic deviations and stochastic signals, acquisition of analog signals, and frequency and rotational speed measurement.
- Students are proficient in the approaches to measurement system design in terms of model assumptions, methods, and achievable results.
- Students are able to analyze and formally describe measurement technology tasks, synthesize possible solutions for measurement systems and assess the properties of the solution obtained.

Content
The module deals with the formal, methodical and mathematical fundamentals for the analysis and design of measurement systems. Focal points of the course are

- Measurement systems and deviations (including scales, the SI systems, modeling of measurement systems)
- Curve fitting (approximation, interpolation)
- Stationary behavior of measurement systems (characteristic curve, errors of the characteristic curve, nonlinearities, adjustment)
- Stochastic measurement errors (probabilistic analysis, samples, statistical test methods, statistic process control, error propagation)
- Stochastic processes (correlational measurements, spectral description of stochastic signals, system identification, matched filter, Wiener filter)
- Digitization of analog signals (sampling, quantization, analog-digital converters, digital-analog converters)
- Frequency and rotational speed measurement (generalized frequency concept, digital speed measurement, detection of direction)

Module grade calculation
The module grade is the grade of the written examination.

Annotation
In the module a lecture, an exercise and an examination are offered.

Workload
The workload includes:

1. attendance in lectures and exercises: 34 h
2. preparation / follow-up of lectures and exercises: 51 h
3. preparation of and attendance in examination: 65 h

total: 150 h = 5 CR

Recommendation
Basic knowledge in the fields of “Probability Theory” as well as “Signals and Systems” is helpful.

M 6.120 Module: Medical Image Processing for Guidance and Navigation [M-ETIT-106672]

Responsible: Prof. Dr.-Ing. Maria Francesca Spadea
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
9	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-ETIT-113425	Medical Image Processing for Guidance and Navigation	9 CR	Spadea

Competence Certificate
The examination takes place within the framework of an oral overall examination of approx. 30 minutes about the lecture including a presentation and discussion of the project developed during the course. The overall impression is rated.

Prerequisites
none

Competence Goal

- The students will be able to analyze, structure and formally describe problems in the field of image guided surgery and therapy.
- The students can apply the methods form medical image processing, surgical navigation, augmented reality for surgery and therapy, medical data science.
- The student will be able to communicate in English technical language.
- The students are able to perform calculations and use the necessary tools for this in a methodologically appropriate way.
- The students are able to critically evaluate them

Content

- This module is designed to provide students with the theoretical and practical aspects of image guidance for minimally invasive surgery and therapy
- This module gives an overview about current status of technology in operation rooms (OR) and advanced radiotherapy bunkers
- Furthermore, this module gives knowledge about image process for quantitative information extraction
- Table of contents
    - Introduction to the course: minimally invasive surgery and medical data science
    - Git introduction
    - Image characteristics
    - Basic point, histogram and masked based operations
    - Similarity metrics, projections
    - Planning imaging, Dicom format, pre processing pipeline
    - Case study: planning in radiotherapy
    - Path planning
    - Pixel based image segmentation: manual segmentation, threshold, region growing
    - Convolution based segmentation: edge detection, morphological filters
    - Case study: neurosurgery and tractography
    - Image registration
    - Atlas based segmentation: SABS, MABS, atlas selection
    - Rendering and computer graphics
    - In room imaging technology
    - Reference system, notation and transformation
    - Localizing systems, tracking and calibration
    - Case study: patient monitoring in radiotherapy, adaptive treatments
    - Lab demonstration
    - Point based registration
    - Surface registration
    - Image features and descriptors (example with SIFT SURF)
    - Radiomics Features
    - Deep Learning in image processing
    - The role of deep learning in radiotherapy
    - Augmentet reality

Module grade calculation
The module grade is the grade of the oral exam.

A bonus can be earned for submitting homework that will be provided during the lecture time.

The exact criteria for awarding a bonus will be announced at the beginning of the lecture period. If the grade in the oral exam is between 4.0 and 1.3, the bonus improves the grade by 0.3 or 0.4.

Bonus points do not expire and are retained for any examinations taken at a later date.

Annotation
The course is limited to a number of 30 participants due to capacity reasons. If necessary, a selection procedure will be carried out. Places will be allocated taking into account the students' study program (students of “Biomedical Engineering” specialization will be preferred, students from Computer Science Program and interest in medical applications will be preferred) and academic progress. Details will be announced on the lecture website.

Workload
The workload includes:

1. attendance in lectures and exercises: 15*6 h = 90 h
2. preparation / follow-up: 15*8 h = 120 h
3. preparation of and attendance in examination: 60 h

A total of 270 h = 9 CR

Recommendation

- Basic knowledge in the field of medical imaging;
- Knowledge of basic programming concept;
- Familiarity with Linux environment;
- Basic knowledge of linear algebra (transformations);
- Attitude towards teamwork and code management in Git;
- It is recommended to have access to a personal computer or desktop

Learning type
Lectures in “Medical Image Processing” (3 SWS), Seminars in “In room imaging modalities” (1 SWS), Tutorials/ Demostrations in Medical image processing and navigation (2 SWS)

M 6.121 Module: Medical Imaging Technology [M-ETIT-106778]

Responsible: Prof. Dr.-Ing. Maria Francesca Spadea
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives (Usage until 3/31/2026)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-113625	Medical Imaging Technology	6 CR	Spadea

Competence Certificate
The examination takes place in form of a written examination lasting 120 minutes.

Prerequisites
none

Competence Goal
For each imaging modality students will be able to:

- identify required energy source;
- analyze the interactions between the form of energy and biological tissue distinguishing desired signal from noise contribution;
- critically interpret the image content to derive knowledge
- evaluate image quality and implementing strategies to improve it.

Moreover, the students will be able to communicate in technical and clinical English languange.

Content

- Basic knowledge of mathematical and physical principles of medical imaging formation, including X-ray based modalities, nuclear medicine imaging, magnetic resonance imaging and ultrasound
- Components of medical imaging devices.
- Assessment of image quality in terms of signal-to-noise-ratio, presence of artifact, spatial, Spectral and temporal resolution
- Safety and protection for patients and workers.

Module grade calculation
The module grade is the grade of the written exam.

A bonus can be earned for voluntary tasks such as:

- presentation and discussion of a specific topic,
- participation to writing the lecture minutes
- implementation of educational tools

The exact criteria for awarding a bonus will be announced at the beginning of the lecture period. If the grade in the oral exam is between 4.0 and 1.3, the bonus improves the grade by 0.3 or 0.4.

Bonus points do not expire and are retained for any examinations taken at a later date.

Workload

1. attendance in lectures an exercises: 15*4 h = 60 h
2. preparation / follow-up: 15*6 h = 90 h
3. preparation of and attendance in examination: 30 h

A total of 180 h = 6 CR

Recommendation
Basic knowledge in the field of physics and signal processing is helpful.

6.122 Module: Medical Imaging Technology II [M-ETIT-106670]

Responsible: Prof. Dr.-Ing. Maria Francesca Spadea
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives (Usage until 9/30/2025)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-113421	Medical Imaging Technology II	3 CR	Spadea

Competence Certificate
The examination takes place in form of a written examination lasting 90 minutes.

Prerequisites
none

Competence Goal
For each imaging modality students will be able to:

- identify required energy source;
- analyze the interactions between the form of energy and biological tissue
- distinguishing desired signal from noise contribution;
- critically interpret the image content to derive knowledge
- evaluate image quality and implementing strategies to improve it.

Moreover, the student will be able to communicate in technical and clinical English language.

Content

- the basic knowledge of mathematical and physical principles of medical imaging formation, including nuclear medicine imaging and magnetic resonance imaging.
- the component of medical imaging devices.
- assessment of image quality in terms of signal-to-noise-ratio, presence of artifact, spatial, spectral and temporal resolution
- safety and protection for patients and workers.

Module grade calculation
The module grade is the grade of the written exam.

Workload

- attendance in class: 15*2h = 30h
- preparation / follow-up: 15*2h = 30h
- exam preparation / attendance: 30h = 90h

A total of 90h = 3 CR

Recommendation

- Basic knowledge in the field of physics and signal processing is helpful.
- The contents of the module "Medical Imaging Technology I" are recommended.

M 6.123 Module: Medical Measurement Technology [M-ETIT-106679]

Responsible: Prof. Dr. Werner Nahm
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives (Usage until 9/30/2025)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-113607	Medical Measurement Technology	6 CR	Nahm

Competence Certificate
The assessment takes place in the form of a written examination lasting 120 min and 120 points.

Prerequisites
none

Competence Goal
The students have analyzed medical issues and identified metrological tasks.

They have proposed a suitable combination of analog circuit technology and digital signal processing and applied it to solve the measurement task.

They have identified the sources of biosignals and explained the underlying physiological mechanisms. They have analyzed the signal properties and derived the resulting requirements for the measurement system.

The students have broken down the measurement chain from the acquisition of the physical measured variable to the presentation of medically relevant information and compared alternative concepts.

Sustainability competence objective: Students have actively shaped their learning process.

Content
Using selected examples, the lecture spans the arc from the medical requirements to the metrological task and the technical realization back to the application. The technical solutions are considered at the levels of measuring principle, measuring method, measuring procedure and measuring system.

The following measuring methods / measuring systems are covered:

- Thermometry
- Blood pressure measurement (invasive, non-invasive, continuous, discontinuous)
- Pulse oximetry
- ECG
- Tonometry
- Audiological measurement procedures (audiometry, tympanometry, otoacoustic emissions)
- EMG
- EEG (spontaneous, evoked)
- CTG
- Bioimpedance analysis
- HZV measurement (Fick's principle, indicator method, US method)
- Spiroergometry

The specialist focus is on

- Sources of biosignals
- sensor technology
- Physical measurement technology
- Analog signal conversion, amplification and filtering
- Influence of disturbance variables, estimation of measurement errors
- Analog-digital conversion, digital signal processing, user interface
- Patient safety / electrical safety
- Standards and norms

Module grade calculation
The module grade is the grade of the written exam.

Bonus points can be awarded for a student contribution to the lecture.

- The student contribution consists of the formulation of learning objectives and questions to check the learning objectives for the lecture units. The corresponding lecture units are made available for selection in ILIAS.
- The students create the student contributions in small groups. They submit their contribution in the form of a PowerPoint presentation in ILIAS by the specified deadline.
- The presentation will be corrected and approved by the lecturer or course tutor if necessary.
- The contribution will be presented by the group in the following lecture unit within the specified period and discussed with the plenum. If necessary, the presenting group takes on board the feedback and creates a revised vision. The final version of the contribution is made available to all lecture participants in ILIAS for exam preparation.
- Bonus points are awarded by the lecturer on the basis of the written paper and the presentation in the plenary session.
- Each participant can earn a maximum of 6 bonus points. Bonus points can only be earned once.
- Participation in the student contributions is voluntary.

The bonus points are credited as follows:

- A maximum of 6 points can be credited to the exam result for the bonus task passed.
- The grade can thus be improved by a maximum of one grade step.
- The total number of points remains limited to 120 points. The bonus points are only taken into account if the exam is passed. Bonus points do not expire and are retained for any examinations taken at a later date.

Workload

- Attendance in the lecture: 2*15*2h = 60h
- Preparation / follow-up: 2*15*2h = 60h
- Preparation and participation in the exam: 2*30h = 60h

total 180h = 6 CR

Recommendation
Required are:

- Basics in physiology and anatomy (e.g. contents of the module "Physiologie und Anatomie für die Medizintechnik")
- Previous knowledge of analog circuit technology (e.g. content of the module "Lineare elektrische Netze") and digital signal processing

6.124 Module: Microactuators [M-MACH-100487]

Responsible: Prof. Dr. Manfred Kohl
Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-MACH-101910	Microactuators	4 CR	Kohl

Competence Certificate
Written exam: 60 min

Prerequisites
none

Competence Goal
- Knowledge of the actuation principles including pros and cons
- Knowledge of important fabrication technologies
- Explanation of layout and function of the microactuators
- Calculation of important properties (time constants, forces, displacements, etc.)
- Development of a layout based on specifications

Content
- Basic knowledge in the material science of the actuation principles
- Layout and design optimization
- Fabrication technologies
- Selected developments
- Applications

The lecture includes amongst others the following topics:

- Microelectromechnical systems: linear actuators, microrelais, micromotors
- Medical technology and life sciences: Microvalves, micropumps, microfluidic systems
- Microrobotics: Microgrippers, polymer actuators (smart muscle)
- Information technology: Optical switches, mirror systems, read/write heads

Workload
lTime of attendance: 15 * 1,5 h = 22,5 h
Preparation and follow up: 15 * 5,5 h = 82,5 h
Exam Preaparation and Exam: 15 h
Total: 120 h = 4 LP

Literature
- Lecture notes
- D. Jendritza, Technischer Einsatz Neuer Aktoren: Grundlagen, Werkstoffe, Designregeln und Anwendungsbeispiele, Expert-Verlag, 3. Auflage, 2008
- M. Kohl, Shape Memory Microactuators, M. Kohl, Springer-Verlag Berlin, 2004
- N.TR. Nguyen, S.T. Wereley, Fundamentals and applications of Microfluidics, Artech House, Inc. 2002
- H. Zappe, Fundamentals of Micro-Optics, Cambride University Press 2010

M 6.125 Module: Microenergy Technologies [M-MACH-102714]

Responsible: Prof. Dr. Manfred Kohl
Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	2

Mandatory			
T-MACH-105557	Microenergy Technologies	4 CR	Kohl

Competence Certificate
Oral exam: 45 min

Prerequisites
none

Competence Goal
The students can:

- describe the energy conversion principles and exemplify them
- explain the underlying concepts of thermodynamics and materials science
- illustrate the layout, fabrication and function of the treated devices
- calculate important properties (time constants, power output, efficiency, etc.)
- develop a layout based on specifications

Content
- Basic physical principles of energy conversion - Layout and design optimization - Technologies - Selected devices - Applications

The lecture includes amongst others the following topics:

- Micro energy harvesting of vibrations using different conversion principles (piezo, electrostatic, electromagnetic, etc.)
- Thermoelectric energy generation
- Novel thermal energy conversion principles (thermomagnetic, pyroelectric)
- Miniature scale solar devices
- RF energy harvesting
- Miniature scale heat pumping
- Solid-state cooling technologies (magneto-, electro-, mechanocalorics)
- Power management
- Energy storage technologies (microbatteries, supercapacito4rs, fuel cells)

Module grade calculation
Module grade calculation
The module grade is the grade of the written exam.

Workload
Time of attendance: 15 * 1,5 h = 22,5 h

Preparation and follow up: 15 * 5,5 h = 82,5 h

Exam Preaparation and Exam: 15 h

Total: 120 h = 4 LP

Literature
- Lecture notes (overhead transparencies) „Micro Energy Technologies“

- Stephen Beeby, Neil White, Energy Harvesting for Autonomous Systems, Artech House, 2010

- Shashank Priya, Daniel J. Inman, Energy Harvesting Technologies, Springer, 2009

M 6.126 Module: Microsystem Technology [M-ETIT-100454]

Responsible: Prof. Dr. Wilhelm Stork
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100752	Microsystem Technology	3 CR	Stork

Competence Certificate
Achievement will be examined in an oral examination (approx. 20 minutes).

Prerequisites
none

M 6.127 Module: Microwave Engineering [M-ETIT-100535]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each term	1 term	German/English	4	1

Mandatory			
T-ETIT-100802	Microwave Engineering	5 CR	Zwick

Competence Certificate
Success control is carried out as part of a written overall examination (120 minutes) of the selected courses, which in total meet the minimum requirement for LP.

Prerequisites
none

Competence Goal
The students have a deep understanding of microwave technology with a focus on passive components of microwave circuit technology. This includes the functioning of the most important microwave components such as waveguides, filters, resonators, couplers, power dividers up to directional lines and circulators. Students are able to understand and describe how these components work. You can transfer this knowledge to other areas of high-frequency technology and use it to analyze and solve high-frequency problems. You are able to apply what you have learned in a practical way.

Content
In-depth lecture on high-frequency technology: The focus of the lecture is the teaching of the functioning of the most important passive microwave components, starting with waveguides, through filters, resonators, power dividers and couplers to directional lines and circulators.

Accompanying the lecture, exercises are given on the lecture material. These are discussed in a large hall exercise and the associated solutions are presented in detail.

Module grade calculation
The module grade is the grade of the written exam.

Annotation
WS: German
SS: English
The exam is in each semester and for every student bilingual.

Workload
The workload includes: Attendance study time lecture / exercise: 45 h Self-study time including exam preparation: 105 h A total of 150 h = 5 LP

Recommendation
Knowledge of the basics of high frequency technology is helpful.

M 6.128 Module: Microwave Engineering Lab [M-ETIT-105300]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each term	1 term	German	4	1

Mandatory			
T-ETIT-110789	Microwave Engineering Lab	6 CR	Zwick

Competence Certificate
To prepare the laboratory tests, each laboratory group has to do some homework together before the experiment and hand in a simple copy to the supervisor immediately before the start of the experiment. The tasks for the experiment as such are processed and logged during the implementation. The protocol should be handed over to the supervisor immediately after the experiment has been carried out. Before each experiment, there is a written exam or oral (approx. 20 min., No aids) the content of the experiment.

Prerequisites
none

Competence Goal
The students have in-depth knowledge of high-frequency components and systems as well as how the most important high-frequency measuring devices work (network analyzer, spectrum analyzer, noise measurement, power measurement, oscilloscope, antenna measurement). They are also familiar with handling high-frequency measuring devices and components. They are able to independently select and operate measuring devices based on the specific applications and to interpret the measurement results. In addition, they are able to work together in a team in a self-organized manner.

Content
Under the motto: "Practical relevance through state-of-the-art equipment and current problems", the students are offered a modern and technically sophisticated high-frequency laboratory at master's level. The aim of the experiments is to deepen the theory imparted in the lectures in practice and to train the use of high-frequency measuring devices and RF components. In groups of 2-4 students, various experiments are carried out and recorded on 8 afternoons. The order and topics of the experiments can vary.

Module grade calculation
The grade for the test execution consists of the preparation, the protocol and the written or oral learning objective control for the respective test. The final grade for the entire laboratory results from the overall impression of the performance. Students who appear unprepared for the respective experiment are not allowed to take part in the experiment. The attempt must be repeated at another time.

Workload
The workload includes:

Attendance study time laboratory: 45 h Test preparation, protocols, test preparation: 135 h A total of 180 h = 6 LP

Recommendation
Knowledge of microwave measurement technology and RF components and systems is helpful.

M 6.129 Module: Microwave Engineering Lab [M-ETIT-106973]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Lab Course)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each term	1 term	English	4	1

Mandatory			
T-ETIT-113938	Microwave Engineering Lab	6 CR	Zwick

Competence Certificate
To prepare the laboratory tests, each laboratory group has to do some homework together before the experiment and hand in a simple copy to the supervisor immediately before the start of the experiment. The tasks for the experiment as such are processed and logged during the implementation. The protocol should be handed over to the supervisor immediately after the experiment has been carried out. Before each experiment, there is a written exam or oral (approx. 20 min., No aids) the content of the experiment.

Prerequisites
none

Competence Goal
The students have in-depth knowledge of high-frequency components and systems as well as how the most important high-frequency measuring devices work (network analyzer, spectrum analyzer, noise measurement, power measurement, oscilloscope, antenna measurement). They are also familiar with handling high-frequency measuring devices and components. They are able to independently select and operate measuring devices based on the specific applications and to interpret the measurement results. In addition, they are able to work together in a team in a self-organized manner.

Content
Under the motto: "Practical relevance through state-of-the-art equipment and current problems", the students are offered a modern and technically sophisticated high-frequency laboratory at master's level. The aim of the experiments is to deepen the theory imparted in the lectures in practice and to train the use of high-frequency measuring devices and RF components. In groups of 2-4 students, various experiments are carried out and recorded on 8 afternoons. The order and topics of the experiments can vary.

Module grade calculation
The grade for the test execution consists of the preparation, the protocol and the written or oral learning objective control for the respective test. The final grade for the entire laboratory results from the overall impression of the performance. Students who appear unprepared for the respective experiment are not allowed to take part in the experiment. The attempt must be repeated at another time.

Workload
The workload includes:

- attendance study time laboratory: 45 h
- test preparation protocols, test preparation: 135 h

A total of 180 h = 6 LP

Recommendation
Knowledge of microwave measurement technology and RF components and systems is helpful.

M 6.130 Module: Microwave Module Design [M-ETIT-105701]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-111375	Microwave Module Design	3 CR	Geist, Zwick

Competence Certificate
The success control is carried out as part of an oral overall examination (approx. 20 minutes) of the selected courses, which is in total meet the minimum requirement for LP.

Prerequisites
none

Competence Goal
After successful completion of the module, students will be able to design complex microwave modules. This includes in particular complete transmit and receive modules consisting of amplifiers, mixers, filters, signal generation, etc. They have a deep understanding of the technological and circuit aspects as well as for embedding in the overall system. The students are able to understand and describe the operation of the individual components and the systems. They are able to transfer this knowledge to other areas of high-frequency technology and thus to analyze and solve high-frequency technical problems. They are able to apply what they have learned in a practical manner.

Content
Applied course on microwave module design: lines on substrates, connectors, limiters, PIN switches, SIW components and filter design, amplifiers, frequency response compensation, phase noise, signal generation, planar mixers, and receiver noise figure.

In addition, during the lecture examples of microwave module design will be implemented and discussed in detail in a state-of-the-art software environment.

Module grade calculation
The module grade is the grade of the oral exam.

Workload
The workload includes:

Attendance study time lecture: 30 h

Self-study time including exam preparation: 60 h

A total of 90 h = 3 LP

Recommendation
Knowledge of the basics of radio frequency technology and communications technology is helpful.

6.131 Module: Microwaves Measurement Techniques [M-ETIT-100424]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German	4	4

Mandatory			
T-ETIT-100733	Microwaves Measurement Techniques	4 CR	Zwick

Competence Certificate
The success control is carried out as part of an oral overall examination (approx. 20 minutes) of the selected courses, which in total meet the minimum requirement for LP.

Prerequisites
none

Competence Goal
The students have an in-depth knowledge of the structure and functioning of microwave measuring devices (signal generator, power measurement, frequency measurement, spectral analyzer, network analyzer). They understand the special features of measuring powers, frequencies and scattering parameters in the microwave range. You can apply the knowledge you have learned in practice and interpret the measurement results. You can analyze and assess possible sources of error in the measurement. You are able to design measurement setups with given measurement values ??and to carry out the measurements correctly.

Content
This lecture contains all basic areas of today's high-frequency measurement techniques, such as power measurement, frequency measurement, spectral analysis and network analysis. Particular attention is paid to the description of those measurement systems and methods that are used in modern applications.

Module grade calculation
The module grade is the grade of the oral exam.

Workload
The workload includes:

Attendance study time lecture / exercise: 45 h

Self-study time including exam preparation: 75 h

A total of 120 h = 4 LP

Recommendation
Knowledge of the basics of high frequency technology is helpful.

M 6.132 Module: Miniaturized Passive Microwave Circuits [M-ETIT-101968]

Responsible: Dr.-Ing. Stefan Wünsch
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	2

Mandatory			
T-ETIT-108389	Miniaturized passive microwave circuits	4 CR	Wünsch

Prerequisites
none

6.133 Module: Mixed-Signal IC Design [M-ETIT-105893]

Responsible: Prof. Dr.-Ing. Ahmet Cagri Ulusoy
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-111845	Mixed-Signal IC Design	3 CR	Ulusoy

Competence Certificate
The success criteria will be determined by an oral examination (30 min.)

Prerequisites
none

Competence Goal
- The students acquire the competencies to mixed-signal advanced microelectronics integrated circuits.
- They have a good understanding of circuit design with linear circuits and "switched-capacitor" circuit techniques.
- They can design a sample-and-hold and track-and-hold circuits and discuss how it can improve an A/D converter's performance.
- They can design an A/D or D/A converter to a given performance specification, choosing an overall architecture, number of stages and internal precision.
- They can design phase lock loop (PLL) circuits, including design details and benefits and disadvantages of each type.
- They are familiar with time-to-digital converters and applications.
- They are familiar with the design of low-power circuits.
- They are able to develop test procedures, test structures and test patterns (ATPG - Automatic Test Pattern Generation) for ASICs.
- They have the basic understanding of the printed circuit board design practices, die-attached and high-density interconnection technology in order to connect the final ASIC to other chips and measurement equipment.

Content
This course covers fundamentals of data converters, Nyquist-rate converters, discrete-time signal processing, central concept of oversampling and noise-shaping, and delta-sigma modulators, phasedlocked loops, assembly and testing procedures of such mixed-signal ICs. Intended for engineers working with digital and analog signals, seeking to learn more about mixed-signal (analog plus digital) circuit design, analysis, and application.

Module grade calculation
The module grade is the grade of the oral examination.

Workload
Each credit point corresponds to an approximately 25-30h of workload in average. Based on this, the amount of work for this lecture is calculated as follows:
1. Attendance to the lectures (15*2=30h)
3. Preparation to the lectures (15*2=30h)
4. Preparation to the oral exam (25h)
Total: 85h

Recommendation
Basic knowledge on analog and digital circuits are recommended.

Literature
1. CMOS Analog Integrated Circuits; Razavi; McGraw-Hill Education
2. Principles of Data Conversion System Design; Razavi; Wiley-IEEE Press
3. Time-to-Digital Converters; Stephan Henzler; Springer Series in Advanced Microelectronics
4. VLSI Technology; Sze; McGraw-Hill

M 6.134 Module: MMIC Design Laboratory [M-ETIT-105464]

Responsible: Prof. Dr.-Ing. Ahmet Cagri Ulusoy
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Lab Course)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each term	1 term	English	4	1

Mandatory			
T-ETIT-111006	MMIC Design Laboratory	6 CR	Ulusoy

Competence Certificate
The written report and the oral presentation are used to mark the course. The overall impression is assessed.

Prerequisites
none

Competence Goal
The students have a comprehensive understanding on the design of monolithic microwave integrated circuits.

The students are able to deduce specifications of individual building blocks in a microwave system and are able to connect these with system level considerations.

They are familiar with various IC fabrication technologies, and are able to identify pros and cons of the various state of the art technologies that are available today.

The students are able to perform the design of a complete microwave sub-system from conception to schematic level design and layout design, and are able to apply high-level design verification methods.

The students can apply their theoretical knowledge on RF engineering using modern design tools.

Content
In this laboratory course, the students will be assigned an RF system and will propose a hardware solution that will meet the requirements of the assigned RF system. The students will then perform schematic level design and system-level simulations of the proposed hardware. The laboratory course will be finalized with a layout implementation and verification of the proposed hardware. The students will learn to use state of the art CAD tools for system level simulations, schematic design, electromagnetic simulations, and layout design and verification in modern IC process technologies. Each RF sub-system will be developed by a group of 3-4 students.

Module grade calculation
The written report and the oral presentation are used to mark the course. The overall impression is assessed.

Workload
Each credit point corresponds approximately to 30h of the student's workload. Here, the average student is expected to reach an average performance. This contains:

1. Attendance to the laboratory tutorials (10*(3)=30h)
2. Preparation to the laboratory tutorials (10*(2)=20h)
3. Implementation of assigned design tasks after each tutorial (10*(8)=80h)
4. Preparation of report and oral presentation (20h)

Total: 150h

Recommendation
Radio-Frequency Integrated Circuits and Systems, Modern Radio Systems Engineering, Microwave Engineering, Electromagnetics and Numerical Calculation of Fields

6.135 Module: Mobile Communications [M-ETIT-105971]

Responsible: Prof. Dr.-Ing. Peter Rost
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-112127	Mobile Communications	4 CR	Rost

Competence Certificate
The success control takes place in the form of an oral examination lasting 25 minutes. Before the examination, there is a preparation phase of 15 minutes in which preparatory tasks are solved.

Prerequisites
none

Competence Goal
Students are enabled to analyze and assess functionalities of mobile communication systems. They learn how to apply and implement fundamental methods of the lecture “Communications Engineering I” in mobile radio networks. Furthermore, students will be enabled to understand requirements and limitations of mobile applications.

Content
At the beginning, this course describes exemplary applications of mobile communications and elaborates on resulting requirements. Based on a solid understanding of those requirements, selected approaches and techniques will be presented that are solving the respective challenges in mobile communication systems. To this end, algorithms as well as system architectures are discussed in order to acquire solid knowledge on the radio network, the core network and the integration with applications and services.

Module grade calculation
Grade of the module corresponds to the grade of the oral exam.

Workload

1. Attendance time in lectures: 15 * 2 h = 30 h
2. Preparation and follow-up of lectures: 15 * 2 h = 30 h
3. Attendance time in excercises: 15 * 1 h = 15 h
4. Preparation and follow-up of excercises: 15 * 1 h = 15 h
5. Preparation for the oral exam: 30 h

In total: 120 h = 4 LP

Recommendation
Knowledge of basic engineering as well as basic knowledge of communications engineering and Previous attendance of the lecture "Communication Engineering I" is recommended. Sound English language skills are required.

M 6.136 Module: Mobile Communications II [M-ETIT-106244]

Responsible: Prof. Dr.-Ing. Peter Rost
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-112679	Mobile Communications II	3 CR	Rost

Competence Certificate
The success control takes place in the form of an oral examination lasting 25 minutes. Before the examination, there is a preparation phase of 15 minutes in which preparatory tasks are solved.

Prerequisites
Basic knowledge of communications engineering. For this purpose previous attendance of the modules "M-ETIT-102103 - Communication Engineering I" and “M-ETIT-105971 - Mobile Communications” is strongly recommended.

Competence Goal
Students are able to analyze and assess functionalities of mobile communication systems. They know how to apply and implement fundamental methods of the lecture “Communications Engineering” in mobile radio networks. Furthermore, students are able to understand requirements and limitations of mobile applications.

This lecture complements the contents of the lecture "Mobile Communications", which mainly deals with aspects of communications access networks. Building on this, the focus of this lecture is on mobile communication architectures, core networks, and specific application scenarios and relevant technologies.

Content
The subject of the lecture is to first introduce a basic mobile communication system architecture including core network and the integration into applications. Based on this, specific core network functions are explained in detail, e.g. user administration, security, quality of service. Finally, specific applications are introduced and it is explained how mobile communication services are integrated in, e.g. industrial networks, connected cars, wide-area IoT applications.

Module grade calculation
Grade of the module corresponds to the grade of the oral exam.

Workload

1. Attendance to the lecture: 15 * 2 h = 30 h
2. Preparation and review: 15 * 2 h = 30 h
3. Preparation for the exam: included in preparation and review = 30 h

In total: 90 h = 3 LP

Recommendation

M 6.137 Module: Mobile Communications Workshop [M-ETIT-106456]

Responsible: Prof. Dr.-Ing. Peter Rost
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each term	1 term	German/English	4	1

Mandatory			
T-ETIT-113063	Mobile Communications Workshop	4 CR	Rost

Competence Certificate
The success controll takes place in the form of other types of examination. The exam consists of report covering the individual experiments. The reports are evaluated as a whole.

Prerequisites
none

Competence Goal
The students are enabled to understand communication protocols and systems. They will be able to comprehend the structure and functioning of mobile radio systems with the help of simple experimental setups. This allows for better understanding of requirements and design principles of mobile radio systems.

Content
The workshop consists of 5 experiments:

- *Setting up a cellular connection using a cellular modem and control commands via a connected computer. Observing the behavior of the modem in different setups.*
- *Measurement and recording of typical features of a mobile phone connection, e.g. received signal power and quality.*
- *Building and analyzing a map showing the different quality indicators in a limited area.*
- *Comparison and synthesis of different maps to understand measurements on different frequency bands and using different setups.*
- *Building an ML algorithm based on measured values to predict quality indicators of the mobile network. This part is divided into a part of building the algorithm and conducting experiments to evaluate its performance.*

Module grade calculation
The grade of the module corresponds to the grade given for all reports (no individual grades for each report are given).

Workload

1. *Attendance: 6 * 3 h = 18 h*
2. *Prepration: 6 * 6 h = 36 h*
3. *Execution of experiments: 6 * 6 h = 36 h*
4. *Review of experiments / report: 6 * 6 h = 36 h*

Overall: 126 h = 4 LP

Recommendation
Basic knowledge of communications engineering. Previous attendance of the lecture "Communication Engineering I" and “Mobile Communications” is recommended. Sound English language skills are required.

M 6.138 Module: Modeling and Simulation (MSc-Modul 05, MS) [M-MACH-102592]

Responsible: Prof. Dr.-Ing. Kai Furmans
Prof. Dr.-Ing. Marcus Geimer
Prof. Dr.-Ing. Luise Kärger
Prof. Dr.-Ing. Carsten Proppe

Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
7	Grade to a tenth	Each winter term	1 term	German/English	4	1

Mandatory			
T-MACH-105297	Modeling and Simulation	7 CR	Furmans, Geimer, Kärger, Proppe

Competence Certificate
written exam, 3 hours

Prerequisites
none

Competence Goal
Students are able to explain models and simulations as part of many disciplines of mechanical engineering. They are able to reproduce the interdisciplinary aspects of typical modeling and simulation techniques in mechanical engineering. The students are proficient in simulation studies from problem formulation to modeling, simulation, verification and validation, ie:

- They are able to formulate the steps necessary to resolve problems arising in engineering, to create appropriate conceptual and mathematical models and to analyze them.

- They are able to develop and implement algorithms for the solution of mathematical models.

- They are able to perform comprehensive and interdisciplinary simulation studies to assess the simulation results and to critically evaluate the quality of the simulation results.

Content
Introduction: Overview, concept formulation, simulation studies.

Time/event-discrete models, event-orientated/process orientated/transaction orientated view, typical model classes (operation/maintenance, storekeeping, loss-susceptible systems).

Time-continuous models with concentrated parameters, model characteristics and model analysis , numerical treatment of ordinary differential equations and differential-algebraic sets of equations. Coupled simulations with concentrated parameters.

Time-continuous models with distributed parameters, description of systems by means of partial differential equations, model reduction, numerical solution procedures for partial differential equations.

Annotation
From SoSe 25, the previous course (7 ECTS) will be replaced by two courses (4 ECTS + 3 ECTS).
One course will be offered in summer semester (Numerical Methods for Engineering Applications (NuMIA), T-MACH-113699, Kärger, 4 ECTS)
and one course is offered in winter semester (Geimer, 3 ECTS, from WiSe 25/26)

Workload
Regular attendance: 42 hours

Self-study: 168 hours

Learning type
Lecture and Tutorials

6.139 Module: Modelling and Simulation of Electrochemical Systems [M-ETIT-100508]

Responsible: Dr.-Ing. Andre Weber
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	1	1

Mandatory			
T-ETIT-100781	Modelling and Simulation of Electrochemical Systems	3 CR	Weber

Prerequisites
none

M 6.140 Module: Modern Radio Systems Engineering [M-ETIT-100427]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Field of Specialization / Field of Specialization: Information and Communication Technology
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-100735	Modern Radio Systems Engineering	4 CR	Zwick

Competence Certificate
The success control is carried out as part of an oral overall examination (approx. 20 minutes) of the selected courses, which in total meet the minimum requirement for LP.

Prerequisites
none

Competence Goal
After attending this course, students will be able to design an analog front end for a radio transmission system at the block diagram level. In particular, the non-idealities of typical components of high-frequency technology and their effects on the overall system performance are part of the knowledge imparted. The students also have an in-depth understanding of
various radar modulation methods and the relationships to approval conditions and performance.

Content
The course gives a general overview of radio transmission systems and their components. The focus is on the system components realized in analog technology and their non-idealities. Based on the physical functioning of the various system components, parameters are derived that allow an examination of their influence on the overall system performance.
The exercise is closely linked to the lecture and mainly consists of computer-based exercises that allow a visualization of the influences of various non-idealities on the overall system performance and demonstrate the practical system design of modern radio transmission systems.

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Each credit point corresponds to approximately 25-30 hours of work (of the student). This is based on the average student who achieves an average performance. The workload includes:
Attendance study time lecture: 30 h
Attendance study time computer exercise SystemVue ESL Design Software / MATLAB: 15 h
Self-study time including exam preparation: 75 h
A total of 120 h = 4 LP

Recommendation
Knowledge of the basics of radio frequency technology and communications technology is helpful.

M 6.141 Module: Modern VLSI Technologies [M-ETIT-106921]

Responsible: Prof. Dr. Jasmin Aghassi-Hagmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-113864	Modern VLSI Technologies	6 CR	Aghassi-Hagmann

Competence Certificate
Success control takes place in form of an oral examination with a duration of approx. 20 minutes. Exercises have to be sucessfully completed before the exam is taken. Further details will be provided at the beginning of the course.

Prerequisites
none

Competence Goal

- The students will gain distinct knowledge in the field of modern CMOS technologies (FinFETs, High-k Gate-Stacks, Below 20nm nodes, Nanosheets).
- They will gain a good understanding of device physics and how to apply the most important design rules to design physical layouts of components and simple circuits.
- The students will be able to compare the functionality (current, performance, noise) of electrically characterized components with simulated devices, while assessing advantages and disadvantages.
- Students will learn to compare different technologies and to perform technology assessments based on benchmark circuit analyses. Understanding of critical paths in circuits for power-performance assessments.

Content
The lecture introduces CMOS technology with the latest technological innovations (high-k materials, gate-last processes, stress engineering, FinFETs, Gate all around FETs, nanosheets, etc.). A detailed understanding of interactions between novel materials, device architectures, and the functionality of basic components will be studied. In addition to physical and circuit properties (variations, self-heating, noise, performance), so-called layout effects, which play a crucial role in advanced CMOS are introduced. Special emphasis is put on the respresentation of technologies in design systems (electronic design automation) as well as SPICE simulations according to the BSIM (Berkeley Simulation Transistor Models) and PSP (Advanced Surface-Potential-Based MOSFET Model) standards. In addition, the use of industrial software (PDKs) for electrical simulation and circuit design will be introduced and practiced in the Excercises. Finally, highly integrated low power systems and their special requirements, wiring concepts and variation modeling are explained.

Module grade calculation
The module grade is the grade of the oral exam.

Workload
The workload includes:

1. Attendance time in laboratory (15h*2=30h)
2. Attendance time in lectures (15h*2=30h)
3. Preparation/follow-up, lecture and exercises (15h*(2+2)=60h)
4. Preparation, written exercises and oral exam (60h)

   Total: 180h

Recommendation
Previous knowledge from the lectures "Festkörperelektronik und Bauelemente" and "Elektronische Schaltungen" is recommended.

6.142 Module: Nano- and Quantum Electronics [M-ETIT-105604]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-111232	Nano- and Quantum Electronics	6 CR	Kempf

Competence Certificate
The assessment of success takes place in the form of a written examination lasting 120min. The grade corresponds to the result of the written examination.

Prerequisites
none

Competence Goal
Students will understand the physical limits of CMOS scaling and will be able to analyze the function of conventional nanoelectronic devices. Students will also understand the operation of novel nanoelectronic and quantum electronic devices and will be able to design this kind of devices that are based on quantum mechanical effects. They develop the ability to design nanoelectronic sensors and devices and can understand and analyze the fabrication methods for nano- and quantum electronic devices.

Content
Nanoelectronics deals with integrated circuits whose typical length scale is well below 100nm. In this regime, physical effects, in particular of quantum mechanical origin, occur and strongly influence the scaling of classical microelectronic devices. This ultimately leads to a new form of electronic components as well as novel operation principles. A special form of nanoelectronics is quantum electronics in which quantum mechanical effects are exploited on purpose to build an entirely new class of devices whose performance reaches far beyond any other microelectronics devices. Well-known examples are superconducting digital electronics which enables to build, for example, microprocessors with clock rates exceeding several 100GHz, or the quantum computer, which will lead to a change of paradigms in the field of information processing.

Within this context, the module "Nano- and quantum electronics" intends to give students an overview of the theoretical and practical aspects of nano- and quantum electronics. In particular, it discusses the following topics:

- Limitations of conventional CMOS technology
- Quantum mechanical effects in the field of nano- and quantum electronics (quantized conductance, Coulomb blockade, tunnel effect, etc.)
- Hot-electron effect
- Nano- and quantum-technological manufacturing and analysis methods
- Nanostructure field-effect transistors
- Quantum dots
- Carbon nanotube field-effect transistor
- Resonant tunnel diodes
- Unipolar resonant tunnel transistor
- Single Electron Transistor (SET)
- Josephson junction based analog and digital electronics
- Quantum bits, quantum computers and quantum computing

The tutorial is closely linked to the lecture and deals with special aspects concerning the development of nano- and quantum electronics. In particular, the development and system integration of such devices for various applications is discussed by means of exercises.

Module grade calculation
The module grade is the grade of the written examination.

Workload
A workload of approx. 175h is required for the successful completion of the module. This is composed as follows:

- Attendance time in lectures and exercises: 18*1.5h + 6*1.5h = 36h
- Preparation and follow-up of lectures: 21*3h= 54h
- Preparation and follow-up of tutorials: 7*5h= 35h
- Preparation for the exam: 50h

Recommendation
Successful completion of the modules "Superconductivity for Engineers" and „Einführung in die Quantentheorie für Elektrotechniker“ is recommended.

M 6.143 Module: Navigation and Localization Techniques [M-ETIT-105881]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-111829	Navigation and Localization Techniques	3 CR	Zwick

Competence Certificate
The success control is carried out as part of an oral overall examination (approx. 20 minutes) of the selected courses, which in total meet the minimum requirement for LP.

Prerequisites
none

Competence Goal
The students are able to understand navigation-related problems and develop appropriate solutions. They have a solid understanding of navigation and positioning principles, corresponding location-dependent measurements, parameter and position estimation as well as position tracking algorithms. With suitable performance measures, they can compare different navigation and localization solutions. For example, the students have sound knowledge on GNSS receivers, IMUs, sensor fusion, and radio navigation for aerospace and land-based applications. In case they face advanced problems, they have ideas how to approach them.

Content
Today navigation systems are an integral part of our daily live. Most of us use a global navigation satellite system (GNSS) receiver integrated in our smartphones to find our way in cities and outdoors. Often, these systems are augmented by localization information from radio systems such as WLAN access points, correction information for assisted GNSS (A-GNSS) or inertial measurement units (IMUs) and magnetometers. In the near future navigation technologies become a key enabler for more efficient, safe, and environmentally friendly automated transport, be it autonomous driving cars and trains or automated landing of airplanes and space vehicles. Therefore, this lecture addresses the following topics:

The first chapter will introduce navigation systems, define common terms, and provide an outline of the lecture as well as organizational details.

The second chapter will discuss navigation and positioning principles based on dead reckoning, landmarks, and electromagnetic waves.

Subsequently, Chapter 3 will present first the estimation problem and lower bounds for estimating location dependent parameters and then suitable estimation methods for location dependent parameters, e.g. received power, time of flight, and direction of arrival of radio signals.

Building on Chapter 3, Chapter 4 will explain snapshot position estimation algorithms including triangulation, trilateration, multilateration, and signature matching. To enable comparisons between different methods, performance bounds and measures are discussed.

Chapter 5 will address the continuous position tracking first with a performance bound and second with different tracking filters such as the Kalman filter and particle filter.

Being familiar with navigation and positioning principles, estimation of location dependent parameters and positions as well as position tracking, Chapter 6 elaborates the architecture and functionality of GNSSs, GNSS receivers, and augmentation systems.

In Chapter 7, inertial navigation and the sensor fusion between IMU and GNSS receiver data is discussed including loosely and tightly coupled approaches.

Particular navigation aspects and systems in the aerospace domain are explained in Chapter 8 whereas Chapter 9 explains navigation and localization for railways and road transport as well as indoors.

Finally, Chapter 10 introduces some advanced research topics in navigation and how to approach them. For instance, multipath and non-line-of-sight propagation, mitigation, and exploitation or cooperative and swarm navigation may be discussed. The topics may be adapted based on current research work and discussions throughout the course.

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Each credit point corresponds to approximately 25-30 hours of work (of the student). This is based on the average student who achieves an average performance. The workload includes:

Attendance study time lecture: 30 h

Self-study time including exam preparation: 60 h

A total of 90 h = 3 LP

Recommendation
Basic knowledge of linear algebra, stochastic, radio frequency technology, and communications technology is helpful.

M 6.144 Module: NMR Methods for Product and Process Analysis [M-CIWVT-105890]

Responsible: apl. Prof. Dr. Gisela Guthausen
Organisation: KIT Department of Chemical and Process Engineering
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German/English	4	1

Mandatory			
T-CIWVT-111843	NMR Methods for Product and Process Analysis	4 CR	Guthausen

Prerequisites
None

Competence Goal
Knowledge about NMR and their applications, basic understanding of the phenomena.

Content
An overview of applications of nuclear magnetic resonance (NMR) will be given together with the basic description of this analytical tool. In the focus of the lectures are typical applications of NMR in chemical and bio engineering. The understanding of this versatile analytical method will be developed on the basis of dedicated examples.

Module grade calculation
The module grade ist the grade of the oral examination.

Workload

- Attendance time (Lecture): 30 h
- Revision course: 30 h
- Exam Preparation: 60 h

Literature
Lehrbücher Kimmich und Callaghan, weitere Literatur wird jeweils in der Vorlesung angegeben.

M 6.145 Module: Nonlinear Control Systems [M-ETIT-100371]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100980	Nonlinear Control Systems	3 CR	Kluwe

Prerequisites
none

6.146 Module: Nonlinear Optics [M-ETIT-100430]

Responsible: Prof. Dr.-Ing. Christian Koos
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	2

Mandatory			
T-ETIT-101906	Nonlinear Optics	6 CR	Koos

Competence Certificate
The oral exam is offered continuously upon individual appointment.

Prerequisites
none

Competence Goal
The students

- understand and can mathematically describe the effect of basic nonlinear-optical phenomena using optical susceptibility tensors,
- understand and can mathematically describe wave propagation in nonlinear anisotropic materials,
- have an overview and can quantitatively describe common second-order nonlinear effects comprising the electro-optic effect, second-harmonic generation, sum- and difference frequency generation, parametric amplification and optical rectification,
- have an overview and can quantitatively describe the Kerr effect and other common third-order nonlinear effects, comprising self- and cross-phase modulation, four-wave mixing, self-focussing, and third-harmonic generation,
- have an overview and can describe nonlinear-optical interaction in active devices such as semiconductor optical amplifiers
- conceive the basic principles of various phase-matching techniques and can apply them to practical design problems,
- conceive the basic principles electro-optic modulators, can apply them to practical design problems, and have an overview on state-of-the art devices,
- conceive the basic principles third-order nonlinear signal processing and can apply them to practical design problems.

Content

1. The nonlinear optical susceptibility: Maxwell´s equations and constitutive relations, relation between electric field and polarization, formal definition and properties of the nonlinear optical susceptibility tensor,
2. Wave propagation in nonlinear anisotropic materials
3. Second-order nonlinear effects and devices: Linear electro-optic effect / Pockels effect, second-harmonic generation, sum- and difference-frequency generation, phase matching, parametric amplification, optical rectification
4. Third-order nonlinear effects and devices: Nonlinear refractive index and Kerr effect, self- and cross-phase modulation, four-wave mixing, self-focussing, third-harmonic generation
5. Nonlinear effects in active optical devices

Module grade calculation
The module grade is the grade of the oral exam.

There is a bonus system based on the problem sets that are solved during the tutorials: During the term, 3 problem sets will be collected in the tutorial and graded without prior announcement. If for each of these sets more than 70% of the problems have been solved correctly, a bonus of 0.3 grades will be granted on the final mark of the oral exam.

Workload
Approx. 180 h – 30 h lectures, 30 h exercises, 120 h homework and self-studies

Literature
R. Boyd. Nonlinear Optics. Academic Press, New York, 1992.
E.H. Li S. Chiang Y. Guo, C.K. Kao. Nonlinear Photonics. Springer Verlag, 2002
G. Agrawal, Nonlinear Fiber Optics, Academic Press, San Diego, 1995.

M 6.147 Module: Numerical Methods [M-MATH-105831]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-MATH-111700	Numerical Methods - Exam	5 CR	Kunstmann, Liao, Reichel

Competence Certificate
Success control takes the form of a written examination (120 minutes).

Prerequisites
none

Competence Goal
Students who pass the module are familiar with basic concepts and ways of thinking on the topic of numerical mathematics. They know different procedures for solving linear and nonlinear problems in numerical mathematics. They are furthermore able to use numerical methods for solving problems from applications in an independent, critical, and needs-based way.

Content
In the lecture basic ideas and numerical methods for the following topics will be presented:

- systems of linear equations, Gauss-algorithm, LR-decomposition, Cholesky decomposition
- eigenvalue problems, von-Mises iteration
- linear optimization (also called linear programming)
- error analysis
- Newton's method
- quadrature, Newton-Cotes formulas
- numerical solution of initial value problems, Runge-Kutta methods
- finite difference method for solving boundary value problems
- finite elements

Module grade calculation
The module grade is the grade of the written exam.

Workload
Approximately 150h workload. The workload includes:

45h - attendance in lectures, exercises and examination

105h – self studies:

- follow-up and deepening of the course content
- solving problem sheets
- literature study and internet research on the course content
- preparation for the module examination

M 6.148 Module: Numerical Methods for Partial Differential Equations [M-ETIT-102311]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German	4	2

Mandatory			
T-ETIT-104595	Numerical Methods for Partial Differential Equations	4 CR	Hohmann

Prerequisites
none

M 6.149 Module: Numerical Methods with Programming Practice [M-MATH-106972]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Fundamentals)
Field of Specialization / Electrical Power Systems and Electromobility (Fundamentals)
Field of Specialization / Field of Specialization: Information and Communication Technology

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-MATH-111700	Numerical Methods - Exam	5 CR	Kunstmann, Liao, Reichel
T-MATH-113937	Numerical Methods - Workshop *This item will not influence the grade calculation of this parent.*	1 CR	Kunstmann, Liao, Reichel

Competence Certificate
Success control takes the form of a written examination (120 minutes)and mandatory participation in the programming workshop. Successful participation in the workshop is confirmed by signing the attendance sheet provided at each practice session.

Prerequisites
none

Competence Goal
Students who pass the module are familiar with basic concepts and ways of thinking on the topic of numerical mathematics. They know different procedures for solving linear and nonlinear problems in numerical mathematics. They are furthermore able to use numerical methods for solving problems from applications in an independent, critical, and needs-based way. The students are capable to implement the numerical procedures they have learned in programming workshop.

Content
In the lecture basic ideas and numerical methods for the following topics will be presented:

- systems of linear equations, Gauss-algorithm, LR-decomposition, Cholesky decomposition
- eigenvalue problems, von-Mises iteration
- linear optimization (also called linear programming)
- error analysis
- Newton’s method
- quadrature, Newton-Cotes formulas
- numerical solution of initial value problems, Runge-Kutta methods
- finite difference method for solving boundary value problems
- finite elements

Module grade calculation
The module grade is the grade of the written exam.

Annotation
The workshop is held twice during the semester, offering students the opportunity to earn an additional credit point (+1) upon successful participation. Students are expected to work on the programming exercises on their own laptops prior to the workshop. During the workshop, solutions to the programming exercises are discussed with the students.

Workload
Approximately 180h workload. The workload includes:

45h - attendance in lectures, exercises and examination

4h - attendance in workshop

131h – self studies:

- follow-up and deepening of the course content
- solving problem sheets
- literature study and internet research on the course content
- preparation for the module examination
- preparation of workshop

M 6.150 Module: Optical Design Lab [M-ETIT-100464]

Responsible: Prof. Dr. Wilhelm Stork
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	2

Mandatory			
T-ETIT-100756	Optical Design Lab	6 CR	Stork

Competence Certificate
The examination consists of an oral exam (20 min).

Prerequisites
none

Competence Goal
The students can apply previous theoretical knowledge in optics to design optical systems based on ray tracing, using a typical optics design software.

The students can apply typical analysis methods to evaluate the imaging performance of optical systems.

The students can recognize aberrations in optical systems and apply methods to compensate them.

Content
The students participating in this lab are given the opportunity to gain practical experience in the use of software tools commonly used in industry for the design of optical elements and systems. Thus improving their knowledge in optical engineering.

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Approximately 162 h workload of the student.

The workload includes:

1. attendance in lectures an exercises: 36 h
   - 9 excercises of 4 h
2. preparation / follow-up: 51 h
   - preparation 9x3 h
   - writing lab reports: 8x3 h
3. preparation of and attendance in examination: 75h

Recommendation
Basic knowledge in optics. The participation in the course Optical Engineering is strongly adviced.

M 6.151 Module: Optical Engineering [M-ETIT-100456]

Responsible: Prof. Dr. Wilhelm Stork
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-100676	Optical Engineering	4 CR	Stork

Competence Certificate
Achievement will be examined in an oral examination (approx. 20 minutes).

Prerequisites
none

Competence Goal
The students from different backgrounds refresh and elaborate their knowledge of engineering optics and photonics. They will get to know the basic principles of optical designs. They will connect these principles with real-world applications and learn about their problems and how to solve them. The students will know about the human view ability and the eye system. After the module they will be able to judge the basic qualities of an optical system by its quantitative data.

After the course, students will:

- understand fundamental optical phenomena and apply it to solve optical engineering problems;
- work with the basic tools of optical engineering, i.e. ray-tracing by abcd-matrices;
- get a broad knowledge on real-world applications of optical engineering;
- learn about the potential of optical design for industrial, medical and day-to-day applications;
- know up-to-date optical engineering problems and its solutions.

Content
The course "Optical Engineering" teaches the practical aspects of designing optical components and instruments such as lenses, microscopes, optical sensors and measurement systems, and optical disc systems (e.g. CD, DVD, HVD). The course explains the layout of modern optical systems and gives an overview over available technology, materials, costs, design methods, as well as optical design software. The lectures will be given in the form of presentations and accompanied by individual and group exercises. The topics of the lectures include:

I. Introduction (Optical Phenomena)

II. Ray Optics (thin/thick lenses, principal planes, ABCD-matrices, chief rays, examples: Eye, IOL)

III. Popular Applications (Magnifying glass, microscope, telescope, Time-of-flight)

IV. Wave Optics (Interference, Diffraction, Spectrometers, LDV)

V. Aberrations I (Coma, defocus, astigmatism, spherical aberration)

VI. Fourier Optics (Periodical patterns, FFT spectrum, airy-patterns)

VII. Aberration II (Seidel and Zernike Aberrations, MTF, PSF, Example: Eye)

VIII. Fourier Optics II (Kirchhoff + Fresnel, contrast, example: Hubble-telescope)

IX. Diffractive Optics Applications (Gratings, holography, IOL, CD/DVD/Blu-Ray-Player)

X. Interference (Coherence, OCT)

XI. Filters and Mirrors (Filters, antireflection, polarization, micro mirrors, DLPs)

XII. Laser and Laser Safety (Laser principle, laser types, laser safety aspects)

XIII. Displays (Pico projectors, LCD, LED, OLED, properties of displays)

Module grade calculation
The module grade is the grade of the oral exam.

Workload
total 120 h, hereof 45 h contact hours (30 h lecture, 15 h problem class), and 75 h homework and selfstudies

Recommendation
Solid mathematical background.

Literature

E. Hecht: Optics

J.W. Goodmann: Introduction to Fourier optics

K.K. Sharma: Optics - Principles and Applications

M 6.152 Module: Optical Engineering and Machine Vision [M-ETIT-106974]

Responsible: Prof. Dr.-Ing. Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Automation, Robotics, and Systems Engineering

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-113941	Optical Engineering and Machine Vision	6 CR	Heizmann

Competence Certificate
The examination takes place in form of a written examination lasting 90 minutes.

Prerequisites
none

Competence Goal

- Students have a sound knowledge of the fundamentals (physical basics of optics, optical imaging, image sensors) and procedures of optical engineering and machine vision.
- Students are proficient in diverse methods for optical imaging, image acquisition, pre-processing and image evaluation and can characterize them based on their prerequisites, model assumptions and results.
- Students are able to analyze and structure optical engineering and machine vision tasks, synthesize possible solutions from optics principles and image processing methods and assess their suitability.

Content
Optical engineering and machine vision are collective terms for using optical signals to solve tasks of information retrieval for technical and other application. They comprise the propagation of light in optical systems, the acquisition of image signals using optical imaging and cameras, the processing of the recorded image signals using (digital) image processing and the evaluation of the image data to obtain useful information from the recorded images.

The module teaches the basics, procedures and exemplary applications of optical engineering and image processing.

The module include in detail:

- Optical Imaging
    - Imaging with a pinhole camera, central projection
    - Imaging using a (single) lens
- Color
    - Photometry
    - Color perception and color spaces
    - Filters
- Sensors for Image Acquisition
    - CCD, CMOS sensors
    - Color sensors and color cameras
    - Quality criteria for image sensors
- Methods of Image Acquisition
    - Measuring optical properties
    - 3D shape capturing
- Image Signals
    - Mathematical model of image signals
    - Systems theory
    - Two-dimensional Fourier transform
    - Noise of digital imaging sensors (EMVA 1288)
- Preprocessing and Image Enhancement
    - Simple image enhancement methods
    - Reduction of systematic errors
    - Attenuation of random disturbances
- Segmentation
    - Region-based segmentation
    - Edge-oriented methods
- Morphological Image Processing
-
    - Binary morphology
    - Gray-scale morphology
- Texture analysis
    - Types of textures
    - Model-based texture analysis
    - Feature-based texture analysis
- Detection
    - Detection of known objects by linear filters
    - Detection of unknown objects (defects)
    - Detection of straight lines (Radon and Hough transform)

Module grade calculation
The module grade is the grade of the written examination.

Workload
The workload includes:

1. attendance in lectures and exercises: 15*4 h = 60 h
2. preparation / follow-up: 15*4 h = 60 h
3. preparation of and attendance in examination: 60 h

A total of 180 h = 6 CR

Recommendation
Basic knowledge of systems theory and signal processing (e.g. from the module “Signals and Systems”) as well as optics is helpful.

Learning type
lecture (3 SWS) and exercise (1 SWS)

6.153 Module: Optical Networks and Systems [M-ETIT-103270]

Responsible: Prof. Dr.-Ing. Sebastian Randel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Field of Specialization: Information and Communication Technology
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-ETIT-106506	Optical Networks and Systems	4 CR	Randel

Competence Certificate
Type of Examination: oral exam

Duration of Examination: 20 min (approx.)

Modality of Exam: Oral exams (approx. 20 minutes) are offered throughout the year upon individual appointment.

Prerequisites
none

Competence Goal
The module provides knowledge about optical networks and systems with applications ranging from photonic interconnects, to fiber-to-the-home (FTTH), optical metro and long-haul networks, and automotive and industrial automation. The role of various network layers will be discussed in conjunction with relevant standards and protocols. Physical-layer specifications of relevant photonic components and system design trade-offs will be introduced.

The students

- get familiar with optical network architectures and protocols
- learn how to design optical communication systems in a variety of application scenarios
- understand how application constraints (performance, cost, energy-efficiency) drive technology innovation
- comprehend the benefits and challenges of using optical communication compared to alternatives (e.g. electrical, and wireless)
- are familiar with relevant standardization bodies and are able to interpret essential aspects of standard documents.

Content
Photonic interconnects: rack-to-rack, board-to-board, chip-to-chip, datacenter interconnects, intensity modulation, direct detection, single-mode fiber vs. multi-mode fiber, serial vs. parallel optics, space-division multiplexing vs. wavelength-division multiplexing, Ethernet (10G, 40G, 100G), Fibre Channel, scaling and energy efficiency.

Access neetworks: fiber-to-the-X, passive optical networks (GPON, EPON, NG-PON2, WDM PON), statistical multiplexing vs. point-to-point

Metro- and long-haul networks:

- System-design aspects: dense WDM (ITU grid), optical amplifiers, chromatic dispersion, coherent detection, optical vs. electronic impairment mitigation, capacity limits.
- Wavelength switching: wavelength selective switch (WSS), reconfigurable optical add-drop multiplexer (ROADM).
- Standards and protocols: synchronous optical networking and synchronous digital hierarchy (SONET/SDH), optical transport network (OTN), generalized multi-protocol label switching (GMPLS), software-defined networking (SDN).

Optical networks in automotive and industrial automotion: polymer-optical fiber (POF), MOST Bus, Profibus and Profinet, optical vs. electrical communication links, overcoming bandwidth limitations using digital signal processing.

Module grade calculation
The module grade is the grade of the oral exam.

Annotation
Will be changed to 6 CR in winter term 25/26.

Workload
total 120 h, hereof 30 h lecture, 15 h problems class and 75 h recapitulation and self-studies.

Recommendation
Interest in communications engineering, networking, and photonics.

Literature

Ivan Kaminow, Tingye Li, Alan E. Willner (Editors), Optical Fiber Telecommunications (Sixth Edition), Elsevier

Rajiv Ramaswami, Kumar N. Sivarajan and Galen H. Sasaki, Optical Networks (Third Edition), Elsevier

M 6.154 Module: Optical Systems in Medicine and Life Science [M-ETIT-103252]

Responsible: Prof. Dr. Werner Nahm
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	5

Mandatory			
T-ETIT-106462	Optical Systems in Medicine and Life Science	3 CR	Nahm

Competence Certificate
Written exam (60 minutes)

Prerequisites
Only one out of the two modules "M-ETIT-100552 - Optische Systeme für Medizintechnik und Life Sciences" and "M-ETIT-103252 - Optical Systems in Medicine and Life Science" is allowed.

Competence Goal
Overall Course Objectives:

This course will allow the students to understand how the basic optical and optoelectronic principles are applied in the design of modern medical devices and routine diagnostic equipment. Besides extending and deepening their expert knowledge in engineering sciences and physics this course will provide profound insight into the applicative, the regulatory and safety and the cost requirements. This will help to be able to understand how the systems are designed to fulfill the requirements.

Furthermore, in this course the students will be introduced into case-based learning. The in-class journal club helps to make the students become more familiar with the advanced literature in the field of study. This interactive format helps to improve the students' skills of understanding and debating current topics of active interest.

Teaching Targets:

The successful participation in this course enables the students to

- derive and formulate system requirements
- layout the system architecture of optical devices
- explain the underlying physical and physiological principles and mechanisms
- elaborate technical and methodological constraints and limitations

present, challenge and debate recent research results

Content
Optical Systems:

- Surgical microscope
- Scanning laser ophthalmoscope (SLO) / Confocal endomicroscope (CEM)
- Optical coherence tomography (OCT) / Optical biometer
- Refractive surgical laser
- Flow-Cytometry

Applied Optical Technologies:

- Magnification and illumination
- Fluorescence and diffuse reflectance imaging
- Confocal laser microscopy
- Low coherence interferometry
- fs-Laser
- Laser scattering (Mie-Therory)

Systems Design and Engineering:

- System architecture

V-Model of Product Development Process

Module grade calculation
The module grade is the grade of the written exam.

Annotation
Language English

Workload
Each credit point corresponds approximately to 30h of the student's workload. Here, the average student is expected to reach an average performance. This contains:

1. Presence during lectures (15 x 1.5 = 22.5h)
2. Preparation and wrap-up of subject matter (57.5h)

Preparation and presentation of one contribution to the in-class journal club (1 x 10h)

Recommendation
Good understanding of optics and optoelectronics.

Literature
M. Kaschke, Optical Devices in Opthalmology and Optometry, Willey-VCH

M 6.155 Module: Optical Technologies for Automotive Applications [M-ETIT-100486]

Responsible: Prof. Dr. Cornelius Neumann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100773	Optical Technologies for Automotive Applications	3 CR	Neumann

Prerequisites
none

M 6.156 Module: Optical Transmitters and Receivers [M-ETIT-100436]

Responsible: Prof. Dr. Wolfgang Freude
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-ETIT-100639	Optical Transmitters and Receivers	6 CR	Freude

Competence Certificate
Oral examination (approx. 20 minutes). The individual dates for the oral examination are offered regularly.

Prerequisites
none

Competence Goal
The students

- understand the peculiarities of optical communications, and how optical signals are generated, transmitted and received,
- know about sampling, quantization and coding,
- learn the basics about noise on reception,
- understand the properties of a linear and a nonlinear optical fibre channel,grasp the idea of channel capacity and spectral efficiency,
- know about various forms of modulation,
- acquire knowledge of optical transmitter elements,
- understand the function of optical amplifiers,
- have a basic understanding of optical receivers,
- know the sensitivity limits of optical systems, and
- understand how these limits are measured.

Content
The course concentrates on basic optical communication concepts and connects them with the properties of physical components. The following topics are discussed:

- Advantages and limitations of optical communication systems
- Optical transmitters comprising lasers and modulators
- Optical receivers comprising direct and heterodyne reception
- Characterization of signal quality

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Approx. 120 hours workload for the student. The amount of work is included:

30 h - Attendance times in lectures
15 h - Exercises
75 h - Preparation / revision phase

Recommendation
Knowledge of the physics of the pn-junction

Literature
Detailed textbook-style lecture notes can be downloaded from the IPQ lecture pages.
Grau, G.; Freude, W.: Optische Nachrichtentechnik, 3. Ed. Berlin: Springer-Verlag 1991. In German. Since 1997 out of print. Electronic version available via w.freude@kit.edu.
Kaminow, I. P.; Li, Tingye; Willner, A. E. (Eds.): Optical Fiber Telecommunications VI A: Components and Subsystems +VI B: Systems and Networks', 6th Ed. Elsevier (Imprint: Academic Press), Amsterdam 2013

M 6.157 Module: Optical Waveguides and Fibers [M-ETIT-100506]

Responsible: Prof. Dr.-Ing. Christian Koos
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-101945	Optical Waveguides and Fibers	4 CR	Koos

Competence Certificate
Type of Examination: Oral exam

Duration of Examination: approx. 20 minutes

Modality of Exam: The written exam is offered continuously upon individual appointment.

Prerequisites
None

Competence Goal
The students

- conceive the basic principles of light-matter-interaction and wave propagation in dielectric media and can explain the origin and the implications of the Lorentz model and of Kramers-Kronig relation,
- are able to quantitatively analyze the dispersive properties of optical media using Sellmeier relations and scientific databases,
- can explain and mathematically describe the working principle of an optical slab waveguide and the formation of guided modes,
- are able to program a mode solver for a slab waveguide in Matlab,
- are familiar with the basic principle of surface plasmon polariton propagation,
- know basic structures of planar integrated waveguides and are able to model special cases with semi-analytical approximations such as the Marcatili method or the effective-index method,
- are familiar with the basic concepts of numerical mode solvers and the associated limitations,
- are familiar with state-of-the-art waveguide technologies in integrated optics and the associated fabrication methods,
- know basic concepts of of step-index fibers, graded-index fibers and microstructured fibers,
- are able to derive and solve basic relations for step-index fibers from Maxwell's equations,
- are familiar with the concept of hybrid and linearly polarized fiber modes,
- can mathematically describe signal propagation in single-mode fibers design dispersion-compensated transmission links,
- conceive the physical origin of fiber attenuation effects,
- are familiar with state-of-the-art fiber technologies and the associated fabrication methods,
- can derive models for dielectric waveguide structures using the mode expansion method,
- conceive the principles of directional couplers, multi-mode interference couplers, and waveguide gratings,
- can mathematically describe active waveguides and waveguide bends.

Content

1. Introduction: Optical communications
2. Fundamentals of wave propagation in optics: Maxwell´s equations in optical media, wave equation and plane waves, material dispersion, Kramers-Kroig relation and Sellmeier equations, Lorentz and Drude model of refractive index, signal propagation in dispersive media.
3. Slab waveguides: Reflection from a plane dielectric boundary, slab waveguide eigenmodes, radiation modes, inter- and intramodal dispersion, metal-dielectric structures and surface plasmon polariton propagation.
4. Planar integrated waveguides: Basic structures of integrated optical waveguides, guided modes of rectangular waveguides (Marcatili method and effective-index method), basics of numerical methods for mode calculations (finite difference- and finite-element methods), waveguide technologies in integrated optics and associated fabrication methods
5. Optical fibers: Optical fiber basics, step-index fibers (hybrid modes and LP-modes), graded-index fibers (infinitely extended parabolic profile), microstructured fibers and photonic-crystal fibers, fiber technologies and fabrication methods, signal propagation in single-mode fibers, fiber attenuation, dispersion and dispersion compensation
6. Waveguide-based devices: Modeling of dielectric waveguide structures using mode expansion and orthogonality relatons, multimode interference couplers and directional couplers, waveguide gratings, material gain and absorption in optical waveguides, bent waveguides

Module grade calculation
The module grade is the grade of the oral exam.

There is, however, a bonus system based on the problem sets that are solved during the tutorials: During the term, 3 problem sets will be collected in the tutorial and graded without prior announcement. If for each of these sets more than 70% of the problems have been solved correctly, a bonus of 0.3 grades will be granted on the final mark of the oral exam.

Workload
Total 120 h, hereof 45 h contact hours (30 h lecture, 15 h tutorial) and 75 h homework and self-studies.

Recommendation
Solid mathematical and physical background, basic knowledge of electrodynamics

Literature
B.E.A. Saleh, M.C. Teich: Fundamentals of Photonics

G.P. Agrawal: Fiber-optic communication systems

C.-L. Chen: Foundations for guided-wave optics

Katsunari Okamoto: Fundamentals of Optical Waveguides

K. Iizuka: Elements of Photonics

M 6.158 Module: Optimal Control and Estimation [M-ETIT-102310]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-104594	Optimal Control and Estimation	3 CR	Hohmann

Prerequisites
none

M 6.159 Module: Optimization and Synthesis of Embedded Systems (ES1) (24143) [M-INFO-100830]

Responsible: Prof. Dr.-Ing. Jörg Henkel
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German/English	4	1

Mandatory			
T-INFO-101367	Optimization and Synthesis of Embedded Systems (ES1)	3 CR	Henkel

Competence Certificate
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
The student can develop embedded systems. They can specify, synthesize and optimize their own hardware. They learn the hardware description language and are familiar with the special boundary conditions of the design of embedded systems.

Content
The cost-effective and error-free development of embedded systems represents a challenge that should not be underestimated and which is having an ever greater influence on the added value of the overall system. In Europe in particular, the design of embedded systems is playing an increasingly important economic role in many sectors of the economy, such as the automotive industry, so that a number of well-known companies are already involved in the development of embedded systems.

The lecture deals comprehensively with all aspects of the development of embedded systems at hardware, software and system level. This includes diverse areas such as modelling, optimization and synthesis of systems.

Workload
90 hrs.

6.160 Module: Optimization of Dynamic Systems [M-ETIT-100531]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Fundamentals)
Field of Specialization / Automation, Robotics, and Systems Engineering
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-100685	Optimization of Dynamic Systems	5 CR	Hohmann

Competence Certificate
The assessment consists of a written exam (120 min) taking place in the recess period.

Prerequisites
none

Competence Goal
- The students know as well the mathematical basics as the fundamental methods and algorithms to solve constraint and unconstraint nonlinear static optimization problems.

- They can solve constraint and unconstraint dynamic optimization by using the calculus of variations approach and the Dynamic Programming method.

- Also they are able to transfer dynamic optimization problem to static problems.

- The students know the mathematic relations, the pros and cons and the limits of the particular optimization methods.

- They can transfer problems from other fields of their studies in a convenient optimization problem formulation and they are able to select and implement suitable optimization algorithms for them by using common software tools.

Content
The module teaches the mathematical basics that are required to solve optimization problems. The first part of the lecture treats methods for solving static optimization problems. The second part of the lecture focuses on solving dynamic optimization problems by using the method of Euler-Lagrange and the Hamilton method as well as the dynamic programming approach.

Module grade calculation
The module grade is the grade of the written exam.

Annotation
Will be changed to 6 CR in winter term 25/26.

Workload
Each credit point stands for an amount of work of 30h of the student. The amount of work includes

1. presence in lecture/exercises/tutorial(optional) (2+1 SWS: 45h1.5 LP)
2. preparation/postprocessing of lecture/exercises (90h3 LP)
3. preparation/presence in the written exam (15h0.5 LP)

M 6.161 Module: Optoelectronic Components [M-ETIT-100509]

Responsible: Prof. Dr.-Ing. Sebastian Randel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-101907	Optoelectronic Components	4 CR	Randel

Competence Certificate
Type of Examination: oral exam

Duration of Examination: approx. 30 minutes

Modality of Exam: Oral examination, usually one examination day per month during the Summer and Winter terms. An extra questions-and-answers session will be held if students wish so.

Prerequisites
none

Competence Goal
Comprehending the physical layer of optical communication systems. Developing a basic understanding which enables a designer to read a device´s data sheet, to make most of its properties, and to avoid hitting its limitations.

The students

- understand the components of the physical layer of optical communication systems
- acquire the knowledge of operation principles and impairments of optical waveguides
- know the basics of laser diodes, luminescence diodes and semiconductor optical amplifiers
- understand pin-photodiodes
- know the systems´sesitivity limits, which are caused by optical and electrical noise

Content
The course concentrates on the most basic optical communication components. Emphasis is on physical understanding, exploiting results from electromagnetic field theory, (light waveguides), solid-state physics (laser diodes, LED, and photodiodes), and communication theory (receivers, noise). The following components are discussed:

- Light waveguides: Wave propagation, slab waveguides, strip wave-guides, integrated optical waveguides, fibre waveguides
- Light sources and amplifiers: Luminescence and laser radiation, luminescent diodes, laser diodes, stationary and dynamic behavior, semiconductor optical amplifiers
- Receivers: pin photodiodes, electronic amplifiers, noise

Module grade calculation
The module grade is the grade of the oral exam.

Annotation
There are no prerequisites, but solution of the problems on the exercise sheet, which can be downloaded as homework each week, is highly recommended. Also, active participation in the problem classes and studying in learning groups are strongly advised.

Workload
total 120 h, hereof 45 h contact hours (30 h lecture, 15 h problem class), and 75 h homework and self-studies

Recommendation
Minimal background required: Calculus, differential equations, Fourier transforms and p-n junction physics.

Literature
Detailed textbook-style lecture notes as well as the presentation slides can be downloaded from the IPQ lecture pages.

Agrawal, G.P.: Lightwave technology. Hoboken: John Wiley & Sons 2004

Iizuka, K.: Elements of photonics. Vol. I, especially Vol. II. Hoboken: John Wiley & Sons 2002

Further textbooks in German (also in electronic form) can be named on request.

6.162 Module: Optoelectronic Measurement Engineering [M-ETIT-100484]

Responsible: Dr.-Ing. Klaus Trampert
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100771	Optoelectronic Measurement Engineering	3 CR	Trampert

Prerequisites
none

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Based on 15 courses per semester, each with 1.5 h presence in the lecture, 2.5 h each Before and after, as well as approx. 2 hours of literature reading and self-exercises, the total workload is 90 hours

6.163 Module: Optoelectronics [M-ETIT-100480]

Responsible: Prof. Dr. Ulrich Lemmer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives (Usage until 9/30/2025)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German	4	3

Mandatory			
T-ETIT-100767	Optoelectronics	4 CR	Lemmer

Competence Certificate
The success check is carried out in the context of a written exam (90 minutes).

Prerequisites
none

Module grade calculation
The module grade is the grade of the written exam.

Workload
1. Presence time in lectures, exercises: 32 h
2. Preparation / Post-processing of the same: 48 h
3. Exam preparation and presence in same: 40 h

M 6.164 Module: Packaging and Interconnects for Power Electronic Systems [M-ETIT-102200]

Responsible: Dr. Thomas Blank
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-104518	Packaging and Interconnects for Power Electronic Systems	3 CR	Blank

Prerequisites
none

M 6.165 Module: Pattern Recognition (24675) [M-INFO-100825]

Responsible: Prof. Dr.-Ing. Jürgen Beyerer
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	2

Mandatory			
T-INFO-101362	Pattern Recognition	6 CR	Beyerer, Zander

6.166 Module: Photometry and Radiometry [M-ETIT-100519]

Responsible: Dr.-Ing. Klaus Trampert
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100789	Photometry and Radiometry	3 CR	Trampert

Prerequisites
none

M 6.167 Module: Photonic Integrated Circuit Design and Applications [M-ETIT-105914]

Responsible: Prof. Dr.-Ing. Christian Koos
Prof. Dr.-Ing. Sebastian Randel

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-111896	Photonic Integrated Circuit Design and Applications	6 CR	

Competence Certificate

- Part 1 – Solutions of problem sets: We will grade your solutions of the various problem sets and design projects. To this end, please upload your solution via the online teaching platform of your respective institution (see above) before the respective deadline. Please merge all pages into a single pdf file, and please use a scanner. Smartphone made snapshots are often illegible, and in this case your solutions cannot not be evaluated. In case there are any technical difficulties with the platforms, you may also submit your solutions by e-mail to picda@ipq.kit.edu before the respective deadline.
- Part 2 - Presentation of one pre-assigned problem set: At the beginning of the term, design projects will be pre-assigned to groups of participants. Each of these groups will explain their approach and results to lecturers and peer students in a short presentation (approx. 15 min), followed by approx. 10 min of public discussion with peer students and professors, and an individual private interview of each group member (approx. 10 min per person).

The overall impression is rated.

Competence Goal
The students understand the basic principles of photonic component design and can apply them to concrete design tasks of increasing complexity and independence, that they will solve in small groups and present to their peers. Doing so they will learn to translate theoretical knowledge gained during the lecture into actionable knowledge used to solve hands-on design tasks. In addition to design principles, students will learn how to satisfy key requirements for making photonic integrated circuits manufacturable and useable in a system environment, such as corner analysis of manufacturing tolerances, design for testability, design for manufacturability, and packaging. In short, we aim at teaching students the skills for hands-on design of manufacturable and application relevant photonic integrated circuits, preparing them to productively contribute to a design team. In addition, we will convey the most recent trends in the application of photonic integrated circuits and let students design a circuit addressing one of these application spaces, giving them a feeling for both the potential as well as the limitations of the technology, so that they may take informed decisions on what systems to integrate in the future.

Content
Lectures:

- Lecture 1: Introduction to silicon photonics
- Lecture 2: Silicon photonics – technology overview
- Lecture 3: Wave propagation in silicon photonic waveguides
- Lecture 4: Mode expansion and orthogonality
- Lecture 5: Coupled-mode theory
- Lecture 6: Selected passive devices
- Lecture 7: Modulators
- Lecture 8: Photodetectors
- Lecture 9: Optical amplifiers and lasers
- Lecture 10: Test and packaging
- Lecture 11: Optical communications
- Lecture 12: Optical metrology
- Lecture 13: Biophotonics and neurophotonics
- Lecture 14: Integrated quantum optics and optical computing

Design lab:

- Problem Set 1: Mode fields and mode expansion
- Problem Set 2: Coupling efficiency and coupled-mode theory
- Design Project A: Optical filter
- Design Project B: Optical transceiver
- Design Project C: Optical communication link

Module grade calculation
The module grade results of the assessment of the solutions of the design projects and problem sets, the presentation of one design project with discussion, and the individual oral interview.

Details will be given during the lecture.

Workload
Each credit point corresponds to approximately 30 hours of work (of the students). This is based on average students who achieve an average performance. The workload includes (e.g. 2 SWS):

1. attendance in lectures an exercises: 15*2 h = 30 h
2. preparation / follow-up: 15*2 h = 30 h
3. preparation of and attendance in examination: 120 h

A total of 180 h = 6 CR

Learning type
In addition to the teaching of fundamental concepts to the extent necessary to enable students to perform practical designs, the lecture will focus from the start on a specific technology platform (silicon-on-insulator) in which the students will solve design problems of increasing complexity with the design suite Lumerical. As the final hands-on problem, students will design an entire photonic subsystem for an application of their choice, leaving free room for creative thinking and self-driven work. Since each group of students will present one of the solved designed problems to their peers, students will get exposed to solutions found for and practical problems encountered in a variety of design tasks, providing them with a wider experience base to draw on for future design.

Since the class will be taught by lecturers from several Universities, all lectures will be streamed live (with the possibility to interact and to ask questions) and made available online. Design tasks will be performed with the Design Suite Lumerical, for which introductory videos will be made available. An online forum will be provided to allow students to ask questions offline to the lecturers as well as to interact with each other, inside and across Universities.

M 6.168 Module: Photonics and Communications Lab [M-ETIT-104485]

Responsible: Prof. Dr.-Ing. Christian Koos
Prof. Dr.-Ing. Sebastian Randel

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Lab Course)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-109173	Photonics and Communications Lab	6 CR	Koos, Randel

Prerequisites
none

M 6.169 Module: Photovoltaics [M-ETIT-100513]

Responsible: Prof. Dr.-Ing. Michael Powalla
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	2

Mandatory			
T-ETIT-101939	Photovoltaics	6 CR	Powalla

Prerequisites
Module "M-ETIT-100524 - Solar Energy" must not have started.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-ETIT-100524 - Solar Energy must not have been started.

6.170 Module: Physical and Data-Based Modelling [M-ETIT-105468]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	4

Mandatory			
T-ETIT-111013	Physical and Data-Based Modelling	6 CR	Hohmann

Competence Certificate
Oral examination of approximately 20 minutes.

Prerequisites
none

Competence Goal

- The students understand the general model concept as well as the characteristics of physical and data-based modeling and can describe their differences.
- They are able to structure complex systems and systematically analyze dependencies of subsystems.
- They are able to explain the general procedure of physical and data-based modeling, apply it to technical systems, and analyze the results.
- They are able to apply causal and non-causal modeling approaches and distinguish between them.
- Students have gained an understanding of generalized, cross-domain, physical relationships and can develop models for electrical, mechanical, pneumatic and hydraulic systems. They can identify states and constraints.
- They can describe the relationship between generalized, cross-domain, physical models and basic procedures of physical-based control and explain their advantages / limitations based on basic knowledge of control engineering.
- They are able to explain different identification procedures for parametric models of static and dynamic systems, select, and apply appropriate procedures for given technical problems.
- Students know basic procedures of learning-based identification and can describe their limitations.
- The students can estimate and judge the effects of disturbances and real conditions on the identification results.

Content
In contrast to the former “Modellbildung und Identifikation”, this course requires a profound knowledge in multivariable systems and optimization. Thus, attendance of the lecture Optimization of Dynamic Systems (ODS) is an absolute precondition to appropriately follow the course! Prior knowledge about (linear) state space representations and realizations, the concept of “zeros” in the state space, and observability is highly recommended!

This course aims at engineering students that focus on a systemic and control engineering curriculum. It encompasses fundamental topics along the complete process of modeling technical systems. Particularly, two major areas will be covered:

On the one hand, physical-based modeling techniques which derive formal model equations based on analyzing the physical first-principles of technical systems. This includes, inter alia, generalized equivalent circuits, bond graphs, port-Hamiltonian systems, variational analysis (Euler-Lagrange of the first kind). Selected topics of physical-based control methods will also be briefly introduced to integrate the complete physical control design in the wider control context and highlight its possible benefits.

On the other hand, data-based identification techniques will be covered which are used to identify concrete model parameters for a given technical system from experimental data sets. When combining the identification with an initial, non-physical, structural set up of model equations, the complete process is often referred to as data-based modeling or black-box modeling.

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Each credit point corresponds to 30 hours of workload (of the student). The workload includes:

1. attendance time in lecture/exercise (3+1 SWS: 60h 2 LP)
2. pre-/postprocessing of the lecture (90h 3 LP)
3. preparation/attendance oral exam (30h 1 LP)

Recommendation

In contrast to the former “Modellbildung und Identifikation”, this course requires a profound knowledge in multivariable systems and optimization. Thus, attendance of the lecture Optimization of Dynamic Systems (ODS) is an absolute precondition to appropriately follow the course! Prior knowledge about (linear) state space representations and realizations, the concept of “zeros” in the state space, and observability is highly recommended (see e.g. Regelung linearer Mehrgrößensysteme (RLM))!

Furthermore, sound understanding of Higher Mathematics I-III, linear electrical network theory and engineering mechanics / physics is required to successfully attend the lecture, exercise tasks / case studies, and exam.

M 6.171 Module: Physical Foundations of Cryogenics [M-CIWVT-103068]

Responsible: Prof. Dr.-Ing. Steffen Grohmann
Organisation: KIT Department of Chemical and Process Engineering
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-CIWVT-106103	Physical Foundations of Cryogenics	6 CR	Grohmann

Competence Certificate
Learning control is an oral examination lasting approx. 30 minutes.

Prerequisites
None

Competence Goal
Understanding of the mechanisms of entropy generation, and the interaction of the first and the second law in thermodynamic cycles; understanding of cryogenic material properties; application, analysis and assessment of real gas models for classical helium I; understanding of quantum fluid properties of helium II based on Bose-Einstein condensation, understanding of cooling principles at lowest temperatures.

Content
Relation between energy and temperature, energy transformation on microscopic and on macroscopic scales, physical definitions of entropy and temperature, thermodynamic equlibria, reversibility of thermodynamic cycles, helium as classical and as quantum fluid, low-temperature material properties, cooling methods at temperatures below 1 K.

Module grade calculation
The grade of the oral examination is the module grade.

Workload

- Attendance time (Lecture): 45 h
- Homework: 45 h
- Exam Preparation: 90 h

Literature
Schroeder, D.V.: An introduction to thermal physics. Addison Wesley Longman (2000)

Pobell; F.: Matter and methods at low temperatures. 3rd edition, Springer (2007)

M 6.172 Module: Physics, Technology and Applications of Thin Films [M-ETIT-105608]

Responsible: Prof. Dr. Sebastian Kempf

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-111237	Physics, Technology and Applications of Thin Films	4 CR	Kempf

Competence Certificate
Oral examination of approximately 20 minutes

Prerequisites
The modul "M-ETIT-102332 - Thin films: technology, physics and applications" and "Thin Films: Technology, Physics and Applications I" may neither be started nor completed.

Competence Goal
Students should be able to discuss interplay between growth conditions of thin films, physical and geometrical properties of nanostructure made of these films, and performance and suitable areas of application of detectors of radiation based on interaction of these nanostructures with electromagnetic power. The knowledge obtained by students should provide a theoretical basis for the most important steps in development of thin film nanoelectronic devices.

Content
Students will get practically oriented information about technology of thin films including different methods of deposition of thin films like magnetron sputtering, thermal evaporation, pulsed laser ablation, about basics of vacuum technology, and about mechanisms of growth of thin films of different materials at different conditions.

Patterning methods (photo- and e-beam lithography, reactive ion etching, ion milling, and lift-off techniques) suitable for nanometer scale features of electronic devices will be considered in details.

Experimental methods of characterization of material, geometrical, optical, physical, superconducting, electron and phonon properties of thin films, nanostructures made of these films, and devices based on these nanostructures will be discussed.

Consideration of technology and physics of thin film structures will be done on example of development of three types of fast and sensitive detectors of electro-magnetic radiation for applications in optical and THz spectral ranges: superconducting nanowire single-photon detector, hot-electron bolometer, and YBCO ps-fast detector of synchrotron emission. Dependence of detector’s performance on their fabrication condition will be analyzed in frame of physical models which describe response mechanisms of the detectors to absorbed radiation.

Practical actualization of the knowledge is possible in frame of Praktikum Nanoelektronik (LVN 23669).

Module grade calculation
The module grade is the grade of the oral exam.

Workload
A workload of approx. 90 h is required for the successful completion of the module. This is composed as follows

1. attendance time in lecture/exercise 18 h
2. pre-/postprocessing of the lecture 24 h
3. preparation/attendance oral exam 48 h

6.173 Module: Physiology and Anatomy for Biomedical Engineering [M-ETIT-105874]

Responsible: Prof. Dr. Werner Nahm
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives (Usage until 9/30/2025)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	2 terms	German	4	2

Mandatory			
T-ETIT-111815	Physiology and Anatomy for Biomedical Engineering	6 CR	Nahm

Competence Certificate
The exmaniation is carried out in the form of a written test of 120 minutes.

The examination includes the contents of Physiologie und Anatomie I (offered every winter term) and Physiologie und Anatomie II (offered every summer term).

Prerequisites
The modules "M-ETIT-100390 - Physiologie und Anatomie I" and "M-ETIT-100391 - Physiologie und Anatomie II" must not been started.

Competence Goal
After studying this module

- students will be able to describe and explain the basic structural and functional principles of the organism at various levels of organization (molecular and cellular to organ and organ system level) in order to classify the organism in its environment,
- have the ability to apply this knowledge to explain higher-level organ and organ system functions,
- know advanced mathematical, scientific and engineering methods for describing physiological processes and are able to apply them,
- be able to describe the functional relationships at the organ and organ system level from a diagnostic and therapeutic perspective and derive the requirements for medical technology systems from this
- and can identify the sources of biosignals and derive connections between physiological parameters and physical measured variables.

Sustainability competence objective: The students have actively shaped their learning process.

Content
Physiologie und Anatomie I (winter semester)

This course provides basic knowledge of the major human organ systems and medical terminology. It is intended for students of technical courses who are interested in physiological issues.

Topic blocks:

- Organizational levels of the organism
- Building blocks of life
  - Proteins
  - Lipids
  - Carbohydrates
  - Lipids
  - Nuleic acids
- Cells
  - Structure
  - Membrane transport processes
  - Protein biosynthesis
  - Cell respiration
  - Nerve cells
  - Muscle cells
- Tissue
  - Tissue types
  - Cell connections
- Sensory organs
  - Eye
  - Hearing

Physiologie und Anatomie II (summer term)

This course expands on the knowledge taught in the first part of the course and introduces additional human organ systems.

Topic blocks:

- The nervous system
  - Anatomy and functional structure
- The cardiovascular system
  - Anatomy and function of the heart
  - Vascular system and blood pressure
- The respiratory system
  - Anatomy and ventilation
  - Gas transport
- The digestive system
  - Anatomy
  - Physiology of digestion
- The endocrine system
  - Endocrine organs
  - Hormonal signal transduction
- Acid-base balance
- Water-electrolyte balance
- Thermoregulation

Module grade calculation
The module grade is the grade of the written exam.

Bonus points can be awarded for a student contribution to the lecture.

- The student contribution consists of the formulation of learning objectives and questions to check the learning objectives for the lecture units. The corresponding lecture units are made available for selection in ILIAS.
- The students create the student contributions in small groups. They submit their contribution in the form of a PowerPoint presentation in ILIAS by the specified deadline.
- The presentation will be corrected and approved by the lecturer or course tutor if necessary.
- The contribution will be presented by the group in the following lecture unit within the specified period and discussed with the plenum. If necessary, the presenting group takes on board the feedback and creates a revised vision. The final version of the contribution is made available to all lecture participants in ILIAS for exam preparation.
- Bonus points are awarded by the lecturer on the basis of the written paper and the presentation in the plenary session.
- Each participant can earn a maximum of 6 bonus points. Bonus points can only be earned once.
- Participation in the student contributions is voluntary.

The bonus points are credited as follows:

- A maximum of 6 points can be credited to the exam result for the bonus task passed.
- The grade can thus be improved by a maximum of one grade step.
- The total number of points remains limited to 120 points. The bonus points are only taken into account if the exam is passed. Bonus points do not expire and are retained for any examinations taken at a later date.

Annotation
This module is part of the Orientation Exam of SPO BSc Medizintechnik § 8. The examination must be taken by the end of the 2nd semester. A repeat examination must be taken by the end of the 3rd semester.

Workload
The workload includes:

- Attendance time in lectures (2 h, 30 appointments each) = 60 h
- Self-study (3 h, 30 appointments each) = 90 h
- Preparation / post-processing = 30 h

<u>Total effort approx. 180 hours = 6 LP</u>

Learning type
Winter/summer term:

- WT: Physiologie und Anatomie I
- ST: Physiologie und Anatomie II

M 6.174 Module: Plasma Sources [M-ETIT-100481]

Responsible: Dr.-Ing. Rainer Kling
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100768	Plasma Sources	4 CR	Heering, Kling

Prerequisites
none

6.175 Module: Plastic Electronics / Polymerelectronics [M-ETIT-100475]

Responsible: Prof. Dr. Gerardo Hernandez Sosa
Prof. Dr. Ulrich Lemmer

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German/English	4	1

Mandatory			
T-ETIT-100763	Plastic Electronics / Polymerelectronics	3 CR	Lemmer

Competence Certificate
Type of Examination: oral exam (approx. 20 minutes)

Prerequisites
none

Competence Goal
The students

- understand the electronic and optical characteristics of organic semiconductors
- know the fundamental differences between organic and conventional inorganic semiconductors.
- have basic knowledge of manufacturing and processing technologies,
- have knowledge of organic light-emitting diodes, organic solar cells and photodiodes, organic field-effect transistors and organic lasers.
- have an overview of the possible applications, markets and development lines for these components.
- are able to work in multidisciplinary teams with engineers, chemists and physicists

Content

1. Introduction
2. Optoelectronic properties of organic semiconductors
3. Organic light emitting diodes (OLEDs
4. Applications in Lighting and Displays
5. Organic FETs
6. Organic photodetectors and solar cells
7. Lasers and integrated optics

Module grade calculation
The module grade is the grade of the oral exam.

Annotation
Lecture and excersises are held as required in German or English.

Workload
1. lecture: 21 h
2. recapitulation and self-studie: 42 h
3. preparation of examniation: 27 h

Recommendation
Knowledge of semiconductor components

Literature
The corresponding documents are available online in the VAB (https://studium.kit.edu/)

M 6.176 Module: Power Electronic Systems in Energy Technology [M-ETIT-106067]

Responsible: Prof. Dr.-Ing. Marc Hiller
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-112286	Power Electronic Systems in Energy Technology	6 CR	Hiller

Prerequisites
none

M 6.177 Module: Power Electronics [M-ETIT-104567]

Responsible: Prof. Dr.-Ing. Marc Hiller
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Fundamentals)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	6

Mandatory			
T-ETIT-109360	Power Electronics	6 CR	Hiller

Competence Certificate
The examination takes place in form of a written examination lasting 120 minutes.

Prerequisites
None

Competence Goal
Students will be familiar with state-of-the-art power semiconductors including their application related features. Furthermore students will be familiar with the circuit topologies for DC/DC and DC/AC power conversion. They know the associated modulation and control methods and characteristics. They are able to analyze the circuit topologies with regard to harmonics and power losses. This also includes the thermal design of power electronic circuits. In addition, they are able to select and combine suitable circuits for given electrical energy conversion requirements.

Content
In the lecture, power electronic circuits for DC/DC and DC/AC power conversion using IGBTs and MOSFETs are presented and analyzed. First, the basic properties of self-commutated circuits under idealized
conditions are elaborated using the DC/DC converter as an example. Then, self-commutated power converters for three-phase applications are presented and analyzed with respect to modulation and their AC
and DC terminal behavior. Based on the real power semiconductor behavior in on- and off-state the device losses are calculated. Furthermore the thermal design of power converters is explained using thermal equivalent circuits of power devices and cooling equipment. The voltage and current stress on the power
semiconductors in switching operation is explained as well as protective snubber circuits allowing a reliable operation within the safe operating area of the devices.

In detail, the following topics are treated:

- Power Semiconductors
- Commutation principles
- DC/DC converters
- Self-commutated 1ph and 3ph DC/AC inverters
- Modulation methods (Fundamental frequency modulation, Pulse width modulation with 3rd harmonic injection, Space vector modulation)
- Multilevel inverters
- Switching behavior in hard and soft switching applications
- Loss calculation
- Thermal equivalent circuits, thermal design
- Snubber circuits.

The lecturer reserves the right to adapt the contents of the lecture to current needs without prior notice.

Module grade calculation
The module grade is the grade of the written exam.

Workload
14x lecture and 14x exercise à 2 h = 56 h
14x wrap-up of the lecture à 1 h = 14 h
14x preparation of the exercise à 2 h = 28 h
Preparation for the exam = 75 h
Examination time = 2 h
Total = approx. 175 h (corresponds to 6 LP)

M 6.178 Module: Power Electronics for Photovoltaics and Wind Energy [M-ETIT-102261]

Responsible: Prof. Dr.-Ing. Marc Hiller
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	2

Mandatory			
T-ETIT-104569	Power Electronics for Photovoltaics and Wind Energy	3 CR	Hiller

Prerequisites
none

M 6.179 Module: Power Network [M-ETIT-100572]

Responsible: Prof. Dr.-Ing. Thomas Leibfried
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	German	4	2

Mandatory			
T-ETIT-100830	Power Network	5 CR	Leibfried

M 6.180 Module: Power System Protection and Automation [M-ETIT-106506]

Responsible: Prof. Dr.-Ing. Thomas Leibfried
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-113164	Power System Protection and Automation	3 CR	Leibfried

Prerequisites
none

6.181 Module: Power Systems and Economy [M-ETIT-100413]

Responsible: Dr.-Ing. Bernd Hoferer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	1	1

Mandatory			
T-ETIT-100725	Power Systems and Economy	3 CR	Hoferer

Prerequisites
none

M 6.182 Module: Practical Aspects of Electrical Drives [M-ETIT-100394]

Responsible: Prof. Dr. Martin Doppelbauer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	2

Mandatory			
T-ETIT-100711	Practical Aspects of Electrical Drives	4 CR	Doppelbauer

Competence Certificate
Success is assessed in a written examination lasting 120 minutes.

Prerequisites
none

Competence Goal
Students understand the function of all components of modern electrical drive systems. They have detailed knowledge of the basic electrical machine types and know the function and physical behavior of loads and other drive components. Students will be able to design electrical drive systems for an application-specific use, taking into account all boundary conditions, and calculate their mechanical and electrical behavior.

Content
The lecture is divided into the following areas

- Drive systems
- electric motors
- Transmission elements
- Drive and load
- Starting, braking, positioning
- Thermal and protection
- Variable speed drives
- Electromagnetic compatibility
- Small drives
- Noise
- Drives with limited movement

Module grade calculation
The module grade is the grade of the written examination.

Annotation
Shift from SoSe to WiSe, does not take place in WiSe24/25 and SoSe25.

Workload
14x lecture + 7x exercises of 1.5 h each = 31.5 h

14x post-processing of lectures à 1 h = 14 h

6x preparation of exercises à 2 h = 12 h

Preparation for the exam = 50 h

Total = 107.5 h (corresponds to 4 CP)

Recommendation
To understand the module, basic knowledge in the field of electrical machines is recommended (acquired, for example, by attending the modules "Electrical Machines and Power Electronics"

M 6.183 Module: Practical Course: Smart Energy System [M-INFO-105955]

Responsible: Prof. Dr. Veit Hagenmeyer
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each term	1 term	German/English	4	1

Mandatory			
T-INFO-112030	Practical Course: Smart Energy System	6 CR	Waczowicz

Competence Certificate
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
After successfully completing the course, students will be able to
- be able to explain the structure and objectives of a smart grid using the Energy Lab 2.0 and the Smart Energy System Simulation and Control Centre (SEnSSiCC),
- be able to name and categorise current research issues in the field of innovative, application-oriented information, automation and system technology for sustainable energy systems,
- analyse a problem from the current research questions of SEnSSiCC as part of a project and develop a strategy for a solution together in a team and
- be able to check, analyse and evaluate the feasibility of results in a laboratory.

Content
As part of the preparation for the internship, project topics are derived from the current research questions of the Smart Energy System Simulation and Control Centre of the Energy Lab 2.0 (https://www.iai.kit.edu/RPE.php). The topics are made available to the participating students in advance of the internship as a list, on the basis of which the students can express their preferences for the respective topics. Based on their stated preferences, the students are assigned to the respective project topics.
The two-week internship begins with a joint kick-off event, which includes an introduction and tour of the Energy Lab 2.0 and the SEnSSiCC as well as a brief presentation of all project topics. Students are provided with current scientific papers on their research topic. During the two-week internship, the groups of students work on their project topics under the supervision of the respective scientists. The students use a laboratory set-up to test their concepts and solutions. Particularly promising approaches can be tested on the real system under the supervision of the scientists. The block course ends with a joint final event at which the students present their solutions and work results.

After the internship, the students follow up the project work by preparing a report on the project topic they have worked on, categorising the work results and reflecting on the work process.
Working in a team is another important aspect of all project topics.
The work placement consists of the following sections:
- Familiarisation with the topic
- Selection of a suitable project topic in consultation with the supervising scientists
- Practical realisation of the project topic
- Presentation of the results (colloquium, research report)

Workload
6 credit points corresponds to approx. 180 working hours, of which
- Attendance time / meetings in large and small groups: 10h
- Select and carry out project work: 140h
- Writing a research report and preparing a presentation: 30 hours

Recommendation
- Knowledge of the fundamentals of energy informatics is a prerequisite.
- Knowledge of the fundamentals of electrical engineering and energy technology is required.
- Knowledge of the basics of mechatronics, data analysis and signal processing is helpful.
- Knowledge of power systems or power electronics is helpful.

6.184 Module: Practical Machine Learning [M-ETIT-106673]

Responsible: Prof. Dr.-Ing. Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-113426	Practical Machine Learning	5 CR	Heizmann

Competence Certificate
Success is assessed by the submission of the scientific essay and the presentation of the team project lasting approx. 30 minutes.

Prerequisites
none

Competence Goal

- After completing the module, students have in-depth knowledge in the field of machine learning.
- They have in-depth knowledge and an overview of various algorithms and methods in the field of machine learning.
- Students are able to describe different concepts and methods of machine learning and recognize connections between different algorithms.
- They are able to communicate with specialists in related disciplines in the field of machine learning and artificial intelligence and to formulate and evaluate solution approaches for tasks in this area.
- Students will gain practical experience in the field of machine learning through the semester-long team project. In particular, students will benefit from mutual feedback on their theoretical work at the end of the semester.

Content
Remarkable progress has been made in the field of artificial intelligence (AI) in recent years. Machine learning (ML) is a sub-discipline of AI that attempts to develop techniques that enable computers to learn from data. The goal of ML methods is to reliably abstract the underlying model for specific tasks.
This lecture covers the theoretical foundations as well as the basic concepts and techniques of machine learning, with a focus on problem solving and practical application. The course offers the opportunity to explore various ML algorithms and their applications in different areas, including computer vision, natural language processing and data mining.
During the course, you will have the opportunity to work on various application tasks and a group project in which you will apply the concepts you have learned to real-world data sets. You will learn how to use common libraries and tools for ML such as Scikit-Learn, TensorFlow and Keras and apply them to real-world datasets. You will also learn how to evaluate the performance of your models and interpret their results.
The lecture style will be a mix of theory and practical applications, with an emphasis on problem solving and hands-on experimentation. The theoretical part of the lecture will be offered as a block course at the beginning of the semester (early/mid April). Students then have the opportunity to work on a problem from the field of
ML alone or in small groups during the semester and present their results in the form of a scientific essay.
The quality assurance of the essay is carried out through a mutual peer review process in which students benefit from mutual feedback both from a technical point of view and with regard to the presentation of content.
The module covers the fundamentals and concepts of machine learning. Topics covered include the following:

- Introduction to machine learning and its applications.
- Data pre-processing and feature engineering techniques.
- Supervised and unsupervised learning algorithms.
- Deep learning techniques such as Convolutional Neural Networks and Recurrent Neural Networks.
- Transfer learning and Tiny ML.
- Evaluation metrics for ML models.
- Hyperparameter tuning and model selection techniques.
- Interpreting the results of ML models.
- ... other interesting topics.

Module grade calculation
The module grade results from the team project accompanying the semester and the presentation of the team project. The overall impression is assessed. Further details will be provided at the beginning of the course.

Workload

- Attendance of the lectures: approx. 21 hours
- Preparation and follow-up of the lecture: approx. 30 hours
- Team project during the semester: approx. 45 hours
- Peer review of the scientific essays
  and presentation of the team project: approx. 45 hours

Total: approx. 141 hours (5 CP)

Recommendation
Basic knowledge of mathematics and linear algebra (matrices, vectors, etc.)
as well as basic knowledge of Python.

Learning type
Block lecture (2 SWS) and practical part (by arrangement within the framework of 1 SWS)

M 6.185 Module: Practical Tools for Control Engineers [M-ETIT-106780]

Responsible: Dr.-Ing. Balint Varga
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-113628	Practical Tools for Control Engineers	4 CR	Varga

Competence Certificate
The examination takes place in form of other types of examination. It consists of an oral overall examination in the amount of 25 minutes and a homework programming task. The examination includes questions from the lecture slides and the presentation of the homework assignment. The homework must be submitted two weeks before of the oral exam. The overall impression is evaluated.

Prerequisites
none

Competence Goal
1. The students will be able to analyze, structure and formally describe problems in the field of practical control engineering.
2. The students are able to use the necessary tools for software projects with control engineering focus.
3. The students can apply the methods

- Modular software development for control engineering problems
- Model Predictive Controller for practical engineering problems
- Inevitable software engineering tools to able to develop control system

Content

- Practical examples from the control engineering problems and modelling tool
  - Robotics examples
  - Human-machine interaction
  - Automotive
- Control solution concepts for these practical problems
- Software development tool

Module grade calculation
The module grade results of the assessment of the oral exam and of the homework programming task. Details will be given during the lecture.

Workload
The workload includes 2 SWS:

1. attendance in lectures and exercises: 15*2 h = 30 h
2. preparation / follow-up: 15*2,5 h = 37,5 h
3. preparation of the homework assignment: 22,5 h
4. preparation of and attendance in examination: 30 h

Sum: 120 h = 4 CR

Recommendation
The contents of the modules “Optimization of Dynamic Systems (ODS)” and “Regelung linearer Mehrgrößensysteme (RLM)” are helpful for the lecture.

M 6.186 Module: Principles of Whole Vehicle Engineering I [M-MACH-105289]

Responsible: Prof.Dipl.-Ing. Rolf Frech
Dr.-Ing. Martin Gießler
Dr.-Ing. Hans-Joachim Unrau

Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
2	Grade to a tenth	Each winter term	1 term	German	4	2

Mandatory			
T-MACH-105162	Fundamentals of Automobile Development I	2 CR	Harrer

Competence Certificate
Written exam, duration approximately 90 minutes.

Auxiliary means: none

Competence Goal
The students have an overview of the entire development process of a passenger car. In addition to the chronological sequence of passenger car development, they also know the national and international legal requirements. They have knowledge of the conflict of objectives between aerodynamics, thermal management and design. They will be able to assess conflicting goals in the area of passenger car development and work out possible solutions.

Content

1. Process of automobile development
2. Conceptual dimensioning and design of an automobile
3. Laws and regulations – National and international boundary conditions
4. Aero dynamical dimensioning and design of an automobile I
5. Aero dynamical dimensioning and design of an automobile II
6. Thermo-management in the conflict of objectives between styling, aerodynamic and packaging guidelines I
7. Thermo-management in the conflict of objectives between styling, aerodynamic and packaging guidelines

Workload
The total work load for this module is about 60 Hours (2 Credits). The partition of the work load is carried out according to the credit points of the courses of the module. The work load for courses with 2 credit points is about 60 hours.

Learning type
Lecture

M 6.187 Module: Principles of Whole Vehicle Engineering II [M-MACH-105290]

Responsible: Prof.Dipl.-Ing. Rolf Frech
Dr.-Ing. Hans-Joachim Unrau

Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
2	Grade to a tenth	Each summer term	1 term	German/English	4	2

Mandatory			
T-MACH-105163	Fundamentals of Automobile Development II	2 CR	Harrer

Competence Certificate
Written exam, duration: approximately 90 minutes.

Auxiliary means: none

Competence Goal
Students are familiar with the selection of suitable materials and with various manufacturing techniques. They have an overview of the acoustics of the vehicle. They are familiar with both the aspects of acoustics in the interior of the vehicle and the aspects of exterior noise. They are familiar with testing the vehicle and assessing the overall vehicle characteristics. They are able to participate competently in the development process of the entire vehicle.

Content

1. Application-oriented material and production technology I
2. Application-oriented material and production technology II
3. Overall vehicle acoustics in the automobile development
4. Drive train acoustics in the automobile development
5. Testing of the complete vehicle
6. Properties of the complete automobile

Workload
The total work load for this module is about 60 Hours (2 Credits). The partition of the work load is carried out according to the credit points of the courses of the module. The work load for courses with 2 credit points is about 60 hours.

Learning type
Lecture

6.188 Module: Process Analysis: Modeling, Data Mining, Machine Learning [M-ETIT-105594]

Responsible: Prof. Dr.-Ing. Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	2

Mandatory			
T-ETIT-111214	Process Analysis: Modeling, Data Mining, Machine Learning	3 CR	Borchert, Heizmann

Prerequisites
none

Module grade calculation
Die Modulnote ist die Note der mündlichen Prüfung.

M 6.189 Module: Project Lab Applied Machine Learning [M-WIWI-106491]

Responsible: Prof. Dr.-Ing. Johann Marius Zöllner
Organisation: KIT Department of Economics and Management
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each term	1 term	German	4	1

Election regulations
Elections in this module must be complete. Election is only possible until the lower bounds are reached.

Compulsory Elective Courses (Election:)			
T-WIWI-109985	Project Lab Cognitive Automobiles and Robots	5 CR	Zöllner
T-WIWI-109983	Project Lab Machine Learning	5 CR	Zöllner

Competence Certificate
The module examination takes the form of an examination on the selected project lab. The control of success is described for each project lab.

Competence Goal
Students

- Are able to solve real-world scientific problems using modern machine learning approaches.
- Are able to specify, adapt, and implement learning-based models to problems.
- Know advantages of learning-based algorithms over traditional solution strategies.

Content
The module is to be regarded as a practice-oriented supplement to theoretical lectures on machine learning.

In the practical course, groups of two to four students each are given scientific tasks in the field of autonomous driving or robotics to be solved using modern ML-based methods. The tasks are of applied nature and mostly additionally require an integrating of the learned methods into existing systems provided by the chair and scientific partners. Due to the application reference, additional conditions are imposed on the learned procedures.

Students analyze the task, research the current state of the art, specify, implement and evaluate their own learning-based methods and present their results in a lecture and final report.

Annotation
The main difference of the internships within the module differ by the rotation in which they are held.

- Project Lab Cognitive Automobile every winter semester.
- Project Lab Machine Learning every summer semester.

Workload
The workload of 5 credit points consists of attendance time at the experimental site for the practical implementation of the selected solution, as well as time for literature research and planning/specification of the selected solution. In addition, a short report and presentation of the work carried out will be prepared.

Recommendation
Theoretical knowledge about machine learning methods is necessary. This can be acquired e.g. by lectures "Machine Learning 1: Basic Methods", or "Machine Learning 2: Advanced Methods". Also lectures of other research groups like "Machine Learning - Basics and Algorithms", "Deep Learning for Computer Vision 1/2" or "Deep Learning and Neural Networks" lay good theoretical foundations for the project lab.

First experiences with deep learning frameworks in Python like PyTorch/Jax/Tensorflow are an advantage.

M 6.190 Module: Project Management in the Development of Products for Safety-Critical Applications [M-ETIT-104475]

Responsible: Dr.-Ing. Manfred Nolle
Prof. Dr.-Ing. Eric Sax

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	2

Mandatory			
T-ETIT-109148	Project Management in the Development of Products for Safety-Critical Applications	4 CR	Nolle

M 6.191 Module: Pulsed Power Technology and Applications (Tutorial) [M-ETIT-105596]

Responsible: Prof. Dr. Georg Müller
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-111216	Pulsed Power Technology and Applications (Tutorial)	5 CR	Müller

Competence Certificate
The examination takes place in form of other types of examination. It consists of oral examination and discussioning the amount of 30 min and a written report about the results of the experiments conducted (one report per group) The overall impression is evaluated. Details will be given during the lecture.

Prerequisites
None

Competence Goal
After completing the course students have theoretical and practical experience on the performance of different types of pulse generators and components (e.g. switches), according measurement techniques and data acquisition systems. Additionally, students will know the basics of electroporation process and analytical methods for material characterization (SEM, EDX, XRD).

Content
The course gives an overview of the features and phenomena of pulse power engineering and emerging applications. Modern applications of pulsed power technologies cover a wide range of topics, ranging from applications in the field of renewable energies as a pretreatment method for biomass conversion, material processing for high temperature applications (e.g. concentrated solar power), inertial confinement fusion to medical applications. Beside the electrical engineering aspect, one goal of this course is to provide basic knowledge in bioelectric and in analytical methods for material characterization. Following topics will be addressed:

- Transmission line based generators
- Marx- generators
- Gas filled spark gaps
- Impedance measurements on biological tissue
- Inactivation of biological cells and electro-orientation
- Surface modification by high-power pulsed electron beams
- Material characterization by SEM, EDX and XRD

The tutorials are carried out in groups of two or three students. Since working with high voltages (up to 120 kV) particular emphasis is put on safety. Therefore, part of the tutorial is an obligatory safety briefing conducted at the beginning of the course.

Module grade calculation
The module grade results of the assessment of the oral examination and a written report. Details will be given during the lecture.

Workload
After completing the course students have theoretical and practical experience on the performance of different types of pulse generators and components (e.g. switches), according measurement techniques and data acquisition systems. Additionally, students will know the basics of electroporation process and analytical methods for material characterization (SEM, EDX, XRD).

The workload includes:

32 h - attendance in tutorials : 8*4 h=32 h

4 h - safety instruction 1*4 h=4 h

112 h - preparation of each tutorial: 8 x14 h = 112 h

A total of 148 h = 5 CR

Recommendation
Knowledge of the content provided in the lecture `Pulsed Power Technology and Applications` is strongly recommended.

6.192 Module: Pulsed Power Technology and Applications (Lecture) [M-ETIT-105595]

Responsible: Prof. Dr. Georg Müller
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-111215	Pulsed Power Technology and Applications (Lecture)	3 CR	Müller

Competence Certificate
The success control takes place within the scope of an overall oral examination (20 minutes).

Prerequisites
none

Competence Goal
The students know the common methods of high-power pulse generation including voltage multiplication by stacking, pulsed generators based on transmission lines, different methods of pulse forming and the related measurement technique. Furthermore, students become familiar with actual scientific and industrial applications of pulsed power.

Content

- Introduction: general principles of pulsed power technology
- Basics: static and dynamic breakdown strength of dielectric materials, energy storage (capacitive, inductive, chemical and mechanical), basic circuits and pulse shaping
- Switches: opening and closing switches
- Systems: pulse forming and transmission lines, voltage and power amplification, high-power generators,
- Diagnostics: metrology in pulsed technique (e.g. capacitve/ inductive sensors)
- Applications: surface treatment by charged particle beams, electrodynamic fragmentation, electroporation and bioelectrics, inertial confinement fusion

An excursion to the Institute for Pulsed Power and Microwave Technology (IHM) at KIT CN will give an insight to different pulsed power facilities and it´s specific applications.

Module grade calculation
The module grade is the grade of the oral examination.

Annotation
Following the lecture period the oral exam is offered by appointment.

Workload
Each credit point corresponds to approximately 25-30 hours of work (by the student). Approximately workload corresponds to:

1. Presence time in lectures (2 SWS: 28 h)
2. Preparation / follow-up of the lecture (30 h)
3. Preparation for oral exam and presence (24 h)

Total 82 h equals to 3 credit points.

M 6.193 Module: Quantum Detectors and Sensors [M-ETIT-105606]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-111234	Quantum Detectors and Sensors	6 CR	Kempf

Competence Certificate
The assessment of success takes place in the form of a written examination lasting 120min. The grade corresponds to the result of the written examination.

Prerequisites
None

Competence Goal
Students know the basics and fundamentals of quantum detectors and sensors and understand how quantum technology can be used to design and realize devices those performance reaches far beyond the limits of any classical sensor or detector. They know the basic components of quantum sensors and detectors, in particular in the field of superconducting quantum technology, and are able to analyze the operation of such detectors and sensors on the basis of circuit diagrams. Students are able to develop quantum sensors and detectors for given applications and know how to consider special requirements in a concrete component.

Content
This module provides a comprehensive overview of the basics and physical principles of quantum detectors and sensors and discusses in detail how quantum technology can be used to design and realize detectors and sensors with performance that reaches far beyond the limits of any classical sensor or detector. The discussion includes particularly an introduction to the basic components of quantum sensors and detectors, especially in the field of superconducting quantum technology, and their fabrication. Using simplified circuit diagrams, the functionality and operation of quantum detectors and sensors such as superconducting quantum interference devices, low-temperature detectors, noise thermometers or superconducting radiation detectors is analyzed. Furthermore, methods and simple models are developed allowing to realize quantum sensors and detectors that are matched to given applications. Within this context, typical applications of quantum detectors and sensors are also discussed.

The tutorial is closely related to the lecture and deals with special aspects concerning the development of quantum detectors and sensors. In particular, the development and system integration of quantum detectors and sensors for applications in precision metrology, particle detection or applied sciences is discussed by means of exercises.

Module grade calculation
The module grade is the grade of the written examination.

Workload
A workload of approx. 180h is required for the successful completion of the module. This is composed as follows:

- Attendance time in lectures and exercises: 21*1.5h + 7*1.5h = 42h
- Preparation and follow-up of lectures: 21*3h= 63h
- Preparation and follow-up of tutorials: 7*5h= 35h
- Preparation for the exam: 40h

Recommendation
Successful completion of the module "Superconductivity for Engineers" is recommended.

6.194 Module: Quantum Engineering [M-ETIT-106954]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Fundamentals)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-113909	Quantum Engineering	6 CR	Kempf

Competence Certificate
The examination takes place in form of a written examination lasting 120 minutes.

Prerequisites
none

Competence Goal
The students will be able to analyze, structure and formally describe problems in the field of quantum engineering. They will particularly be able to understand the difference between classical and quantum engineering. They will be able to analyze, design and implement concepts, technology, circuits and algorithms in the fields of quantum computing, quantum communication and quantum sensing. Moreover, the students will be able to critically evaluate existing concepts, methods, technologies, and circuits regarding complexity, suitability and applicability.

Content
This module introduces the emerging field of quantum engineering. For this, the module (1) addresses physics basics and the related mathematical framework, (2) discusses recent realizations of engineered quantum systems for the sub-fields of quantum computing, quantum communication and quantum sensing, (3) introduces hardware designs and practical realizations, (4) summarizes quantum information processing aspects, and (5) discusses real implementations and applications.

The module particularly addresses:

1. Basics of quantum mechanics and the mathematical frameworks (state vector, postulates of quantum mechanics, bra-ket-formalism, superposition, entanglement and Bell inequalities, probability density matrix formalism, pure and mixed states, squeezing)
2. Description of light and photons
3. Decoherence and coherence of quantum systems, quantum errors
4. Basics of quantum computers: quantum gates, gate-based quantum computing architecture
5. Quantum algorithms: quantum random number generator, quantum penny flip, Deutsch-Josza-Algorithm, Grover algorithm, quantum Fourier transform, Shor algorithm, quantum phase estimation, HHL algorithm
6. Quantum error correction: Concepts and architectures
7. Hardware realization of quantum bits: DiVincenzo criteria, Cooper pair box, phase qubit, flux qubit, transmon, quantum dots etc.
8. Examples of recent quantum computing architectures
9. Quantum sensing: Atomic clocks, NV centers, SQUIDs, parametric amplifiers, quantum imaging, interaction free quantum measurements, interferometry at the quantum limit, quantum logic spectroscopy,
10. Quantum communication: Quantum cryptography, quantum key distribution, quantum teleportation, entanglement swapping, quantum repeater and quantum networks

As the lecture intends to include recent advancements of the field of quantum engineering, the actual content might slightly differ from the announced topics.

The exercises are closely related to the lecture and deal with special aspects concerning quantum engineering. Moreover, it deepens the student's knowledge by discussing various examples.

Module grade calculation
The module grade is the grade of the written exam.

Workload
The workload includes:

1. Attendance in lectures: 15 * 3 h = 45 h
2. Attendance in exercices: 15 * 1 h = 15 h
3. Preparation and follow up of lectures and exercises: 90 h
4. Preparation of and attendance in examination: 30 h

A total of 180 h.

Recommendation
Basic knowledge of quantum mechanics and the related mathematical framework, as taught, for example, within the module “M-ETIT-106264 – Introduction to Quantum Information Processing” is strongly recommended.

Learning type
“Lecture Quantum Engineering” (3 SWS) and “Exercises to Quantum Engineering” (1 SWS)

6.195 Module: Quantum Machine Learning [M-ETIT-105889]

Responsible: Prof. Dr.-Ing. Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-111838	Quantum Machine Learning	3 CR	Heizmann

Prerequisites
none

M 6.196 Module: Radar Systems Engineering [M-ETIT-100420]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-ETIT-100729	Radar Systems Engineering	6 CR	Zwick

Competence Certificate
Success control is carried out as part of a written overall examination (120 minutes) of the selected course, which in total meets the minimum requirement for LP.

Prerequisites
none

Competence Goal
Students can name the basic radar principles and explain how they work, their primary uses and their advantages and disadvantages. They are able to characterize the basic characteristics and mechanisms of propagation of electromagnetic waves and to apply the relevant equations. You can evaluate the influence of various system parameters on accuracy, resolution, false alarm rate, etc. and optimize systems. You can describe different radar system configurations (CW, FMCW, pulse, SAR) and apply the relevant radar signal processing methods. They are especially able to use and use the technologies and system configurations for the radars of the future for surveillance, automotive and industrial applications for research and development. In this lecture system technology is specifically taught.

Content
Based on electromagnetic field theory, the lecture teaches the basics of radar principles and their system technology. An insight into the system hardware is given and processing techniques are presented. All relevant, known radar systems (CW, FMCW, pulse and synthetic aperture radar) are described in detail. The system technology for the radars of the future is specifically dealt with. The reflective properties of radar targets are analyzed for their classification. In particular, polarimetry is taught. In this lecture, students learn how system technology contributes to the implementation of a radar system.

Module grade calculation
The module grade is the grade of the written exam.

Workload
Each credit point corresponds to approximately 25-30 hours of work (of the student). This is based on the average student who achieves an average performance. The workload includes:

Attendance study time lecture: 44 h

Attendance time computer exercise: 16 h

Self-study time including exam preparation: 120 h

A total of 180 h = 6 LP

M 6.197 Module: Radio Frequency Integrated Circuits and Systems [M-ETIT-105123]

Responsible: Prof. Dr.-Ing. Ahmet Cagri Ulusoy
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	2

Mandatory			
T-ETIT-110358	Radio Frequency Integrated Circuits and Systems	6 CR	Ulusoy

Competence Certificate
The success criteria will be determined by an oral examination (approx. 20-30 min.)

Competence Goal

- The students acquire a comprehensive understanding in the design of monolithic integrated circuits for millimeter-wave frequencies, and they can apply the acquired knowledge using modern design tools.
- They have a good understanding of the critical performance parameters of high-frequency circuits such as stability, power gain and efficiency and reflection coefficient.
- They can describe the benefits and disadvantages of modern transistor technologies for millimeter-wave applications.T
- They can identify potential applications of integrated millimeter-wave circuits and understand the specific requirements of each application.
- They are familiar with basic elements of a high-frequency system, which consists of linear and non-linear circuits, low-noise and power amplifiers, as well as oscillators, switches and frequency converting circuits such as frequency multipliers and mixers.

Content
In this lecture the theory and the design methodology of monolithic integrated millimeter-wave circuits will be
studied in detail. The focus of the lecture is on the active linear and non-linear circuits in high-frequency frontends up to an application frequency of 300 GHz. In addition to this, fundamental topics such as impedance matching, stability, performance parameters of high-frequency transistors, and properties of active and passive circuit elements will be studied in detail. The operation principal of critical building blocks of a millimeter-wave system will be introduced including low-noise and power amplifiers, mixers, oscillators and switches. In the workshop, the students will have the chance to apply the acquired theoretical knowledge to design a millimeter-wave frontend using state-of-the art integrated circuit technology.

Module grade calculation
The module grade is the grade of the oral examination.

Workload
1. Attendance to the lectures (15*(2)=30h)
2. Attendance to the exercises (15*(2)=30h)
3. Preparation to the lectures and exercises (15*(2+2)=60h)
4. Preparation to the oral exam (40h)

Total: 160h

Recommendation
The lecture materials to „Grundlagen der Hochfrequenztechnik“ and „Halbleiterbauelemente“ are recommended.

6.198 Module: Radio Receivers [M-ETIT-103241]

Responsible: Prof. Dr. Friedrich Jondral
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-106431	Radio Receivers	3 CR	Jondral

Prerequisites
none

M 6.199 Module: Radio-Frequency Electronics [M-ETIT-105124]

Responsible: Prof. Dr.-Ing. Ahmet Cagri Ulusoy
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-ETIT-110359	Radio-Frequency Electronics	5 CR	Ulusoy

Competence Certificate
The success criteria will be determined by a written examination of 120 min.

Prerequisites
none

Competence Goal
* The students have a comprehensive understanding of the theory and the basic design methodology of electronic circuits at high frequencies.

* They understand the limitations of active and passive circuit elements including various transistor technologies and their impact on the applications.

* They understand the limitations and how linear network theory is applied for advanced electronic circuits.

* The students can apply the acquired theoretical knowledge using modern design tools.

Content
In this module, the theory and design methodology of high-frequency electronic circuits will be studied in detail. The focus of the module is on the fundamentals of active linear circuits. The important topics are phasor analysis, resonance, impedance matching networks, two-port parameters of transistors, high-frequency behavior of basic amplifier circuits, practical design methodology of high-frequency amplifiers, and introduction to the design of non-linear circuits using the linear design methodology. In the tutorial the student will have the possibility to apply their theoretical knowledge by designing, assembling and testing a radio-frequency amplifier in the framework of a design challeng

Module grade calculation
The module grade is the grade of the written examination.

Workload
1. Attendance to the lectures (15*(2)=30h)
2. Attendance to the exercises and workshop (15*(2)=30h)
3. Preparation to the lectures, exercises and workshop (15*(1+1)=30h)
4. Preparation of homework assignments and to the oral exam (20+40h)

Total: 150h = 5L

Recommendation
Contents of the modules "Linear electrical networks" and "Electronic circuits".

M 6.200 Module: Radio-Frequency Electronics [M-ETIT-106955]

Responsible: Prof. Dr.-Ing. Ahmet Cagri Ulusoy
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Fundamentals)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-113910	Radio-Frequency Electronics	6 CR	Ulusoy

Competence Certificate
The examination takes place in form of a written examination lasting 120 minutes.

Prerequisites
none

Competence Goal

- The students have a comprehensive understanding of the theory and the basic design methodology of RF and microwave circuits up to 300 GHz.
- They understand the limitations of active and passive circuit elements at high frequencies and their impact on the applications.
- They understand the limitations and how linear network theory is applied at higher frequencies.
- The students can apply the acquired theoretical knowledge to modern RF design problems.

Content
In this lecture, the theory and design methodology of RF electronic circuits will be studied in detail. The focus of the lecture is on the fundamentals of active and passive linear circuits. The important topics are:

- Phasor analysis and resonance,
- Electromagnetic theory, transmission lines and waveguides,
- Impedance matching networks,
- Two-port parameters of RF components and microwave network analysis,
- Feedback and stability analysis,
- High-frequency behavior of basic amplifier circuits, RF amplifiers design techniques,
- Microwave power dividers, couplers and filters

Module grade calculation
The module grade is the grade of the written examination.

Workload
The total effort for this lecture is estimated as following:

1. Attendance to the lectures (15*(3)=45h)
2. Attendance to the exercises (15*(1)=15h)
3. Preparation to the lectures and exercises (17*(3+1)=68h)
4. Preparation to the exam (52h)

A total of 180h

Recommendation
Basic knowledge of linear electrical networks and electronic circuits is recommended (e.g. M-ETIT-106417 – Lineare Elektrische Netze; M-ETIT-104465 – Elektronische Schaltungen).

M 6.201 Module: Real Time Control of Electrical Drives [M-ETIT-105916]

Responsible: Dr.-Ing. Andreas Liske
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-111898	Real Time Control of Electrical Drives	6 CR	Liske

Workload
Jeder Leistungspunkt (Credit Point) entspricht ca. 25-30h Arbeitsaufwand (des Studierenden). Hierbei ist vom durchschnittlichen Studierenden auszugehen, der eine durchschnittliche Leistung erreicht.

56h = 22x V à 2h + 3x Ü à 4h

21h = 21x Nachbereitung von V à 1 h

12h = 3x Vorbereitung von Ü à 4 h

80h = Vorbereitung zur Prüfung

Summe = 169 h (entspricht 6 LP)

M 6.202 Module: Refrigeration B - Foundations of Industrial Gas Processing [M-CIWVT-104354]

Responsible: Prof. Dr.-Ing. Steffen Grohmann
Organisation: KIT Department of Chemical and Process Engineering
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-CIWVT-108914	Refrigeration B - Foundations of Industrial Gas Processing	6 CR	Grohmann

Competence Certificate
The examination is an oral examination with a duration of about 30 minutes (section 4 subsection 2 number 2 SPO).

Prerequisites
None

Competence Goal
Understanding the principles of different processes for gas liquefaction and gas separation; Analysing processes in order to reveal the sources of energy demand; Applying the principles of thermodynamics of mixtures and analysing the states of fluids in rectification columns; Assessing the potential of technical concepts from a thermodynamic point of view

Content
Gas liquefaction processes, process analyses, refrigerators and mixed-refrigerant cycles, gas separation by low-temperature rectification, air separation and extraction of noble gasses, processing and separation of natural gas, ethylene production, processing of H2-enriched gas mixtures, storage and transport of liquefied gasses

Module grade calculation
The grade of the oral examination is the module grade.

Workload

- Attendance time (Lecture): 45 h
- Homework: 45 h
- Exam Preparation: 90 h

M 6.203 Module: Renewable Energy-Resources, Technologies and Economics [M-WIWI-100500]

Responsible: Prof. Dr. Russell McKenna
Organisation: KIT Department of Economics and Management
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-WIWI-100806	Renewable Energy-Resources, Technologies and Economics	3,5 CR	Jochem

Competence Certificate
The assessment consists of a written exam according to Section 4(2), 1 of the examination regulation.

Prerequisites
None

Competence Goal
The student:

- understands the motivation and the global context of renewable energy resources.
- gains detailed knowledge about the different renewable resources and technologies as well as their potentials.
- understands the systemic context and interactions resulting from the increased share of renewable power generation.
- understands the important economic aspects of renewable energies, including electricity generation costs, political promotion and marketing of renewable electricity.
- is able to characterize and where required calculate these technologies.

Content
1. General introduction: Motivation, Global situation

2. Basics of renewable energies: Energy balance of the earth, potential definition

3. Hydro

4. Wind

5. Solar

6. Biomass

7. Geothermal

8. Other renewable energies

9. Promotion of renewable energies

10. Interactions in systemic context

11. Excursion to the “Energieberg” in Mühlburg

Workload
The total workload for this course is approximately 105.0 hours. For further information see German version.

Literature
Elective literature:

- Kaltschmitt, M., 2006, Erneuerbare Energien : Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, aktualisierte, korrigierte und ergänzte Auflage Berlin, Heidelberg : Springer-Verlag Berlin Heidelberg.
- Kaltschmitt, M., Streicher, W., Wiese, A. (eds.), 2007, Renewable Energy: Technology, Economics and Environment, Springer, Heidelberg.
- Quaschning, V., 2010, Erneuerbare Energien und Klimaschutz : Hintergründe - Techniken - Anlagenplanung – Wirtschaftlichkeit München : Hanser, Ill.2., aktualis. Aufl.
- Harvey, D., 2010, Energy and the New Reality 2: Carbon-Free Energy Supply, Eathscan, London/Washington.
- Boyle, G. (ed.), 2004, Renewable Energy: Power for a Sustainable Future, 2ndEdition, Open University Press, Oxford.

M 6.204 Module: Robotics - Practical Course [M-INFO-102522]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	3

Mandatory			
T-INFO-105107	Robotics - Practical Course	6 CR	Asfour

Competence Certificate
See partial Achievements (Teilleistung)

Prerequisites
See partial Achievements (Teilleistung)

Competence Goal
The student knows concrete solutions for different problems in robotics. He/she uses methods of inverse kinematics, grasp and motion planning, and visual perception. The student can implement solutions in the programming languages C++ and Python with the help of suitable software frameworks.

Content
The practical course is offered as an accompanying course to the lectures Robotics I-III. Every week, a small team of students will work on solving a given robotics problem. The list of topics includes robot modeling and simulation, inverse kinematics, robot programming via state charts, collision-free motion planning, grasp planning, robot vision and robot learning.

Workload
Practical course with 4 SWS, 6 LP
6 LP corresponds to 180 hours, including
2 hours introductory event
18 hours initial familiarization with the software framework
120 hours group work
40 hours attendance time

Recommendation
Attending the lectures Robotics I – Introduction to Robotics, Robotics II: Humanoid Robotics, Robotics III - Sensors and Perception in Robotics and Mechano-Informatics and Robotics is recommended.

M 6.205 Module: Robotics I - Introduction to Robotics [M-INFO-100893]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: Electives (Usage until 9/30/2025)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German/English	4	3

Mandatory			
T-INFO-108014	Robotics I - Introduction to Robotics	6 CR	Asfour

Competence Certificate
See partial achivements (Teilleistung)

Prerequisites
See partial achivements (Teilleistung)

Competence Goal
The students are able to apply the presented concepts to simple and realistic tasks from robotics. This includes mastering and deriving the mathematical concepts relevant for robot modeling. Furthermore, the students master the kinematic and dynamic modeling of robot systems, as well as the modeling and design of simple controllers. The students know the algorithmic basics of motion and grasp planning and can apply these algorithms to problems in robotics. They know algorithms from the field of image processing and are able to apply them to problems in robotics. They are able to model and solve tasks as a symbolic planning problem. The students have knowledge about intuitive programming procedures for robots and know procedures for programming and learning by demonstration.

Content
The lecture provides an overview of the fundamentals of robotics using the examples of industrial robots, service robots and autonomous humanoid robots. An insight into all relevant topics is given. This includes methods and algorithms for robot modeling, control and motion planning, image processing and robot programming. First, mathematical basics and methods for kinematic and dynamic robot modeling, trajectory planning and control as well as algorithms for collision-free motion planning and grasp planning are covered. Subsequently, basics of image processing, intuitive robot programming especially by human demonstration and symbolic planning are presented.

In the exercise, the theoretical contents of the lecture are further illustrated with examples. Students deepen their knowledge of the methods and algorithms by independently working on problems and discussing them in the exercise. In particular, students can gain practical programming experience with tools and software libraries commonly used in robotics.

Workload
Lecture with 3 SWS + 1 SWS Tutorial, 6 LP
6 LP corresponds to 180 hours, including
15 * 3 = 45 hours attendance time (lecture)
15 * 1 = 15 hours attendance time (tutorial)
15 * 6 = 90 hours self-study and exercise sheets
30 hours preparation for the exam

M 6.206 Module: Robotics II - Humanoid Robotics [M-INFO-102756]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	3

Mandatory			
T-INFO-105723	Robotics II - Humanoid Robotics	3 CR	Asfour

Competence Certificate
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
The students have an overview of current research topics in autonomous learning robot systems using the example of humanoid robotics. They are able to classify and evaluate current developments in the field of cognitive humanoid robotics.

The students know the essential problems of humanoid robotics and are able to develop solutions on the basis of existing research.

Content
The lecture presents current work in the field of humanoid robotics that deals with the implementation of complex sensorimotor and cognitive abilities. In the individual topics different methods and algorithms, their advantages and disadvantages, as well as the current state of research are discussed.

The topics addressed are: Applications and real world examples of humanoid robots; biomechanical models of the human body, biologically inspired and data-driven methods of grasping, imitation learning and programming by demonstration; semantic representations of sensorimotor experience as well as cognitive software architectures of humanoid robots.

Workload
Lecture with 2 SWS, 3 CP.
3 LP corresponds to approx. 90 hours, thereof:
approx. 15 * 2h = 30 Std. Attendance time
approx. 15 * 2h = 30 Std. Self-study prior/after the lecture
approx. 30 Std. Preparation for the exam and exam itself

Recommendation
Having visited the lectures on Robotics I - Introduction to Robotics and Mechano-Informatics and Robotics is recommended.

6.207 Module: Robotics III - Sensors and Perception in Robotics (24635) [M-INFO-104897]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-INFO-109931	Robotics III - Sensors and Perception in Robotics	3 CR	Asfour

Competence Certificate
See partial achivements (Teilleistung)

Prerequisites
See partial achivements (Teilleistung)

Competence Goal
Students can name the main sensor principles used in robotics.

Students can explain the data flow from physical measurement through digitization to the use of the recorded data for feature extraction, state estimation and semantic scene understanding.

Students are able to propose and justify suitable sensor concepts for common tasks in robotics.

Content
The lecture supplements the lecture Robotics I with a broad overview of sensors used in robotics. The lecture focuses on visual perception, object recognition, semantic scene interpretation, and (inter-)active perception. The lecture is divided into two parts:

In the first part a comprehensive overview of current sensor technologies is given. A basic distinction is made between sensors for the perception of the environment (exteroceptive) and sensors for the perception of the internal state (proprioceptive).

The second part of the lecture concentrates on the use of exteroceptive sensors in robotics. The topics covered include tactile exploration and visual data processing, including advanced topics such as feature extraction, object localization,semantic scene interpretation, and (inter-)active perception.

Workload
Lecture with 2 SWS, 3 LP
3 LP corresponds to 90 hours, including
15 * 2 = 30 hours attendance time
15 * 2 = 30 hours self-study
30 hours preparation for the exam

Recommendation
Attending the lecture Robotics I – Introduction to Robotics is recommended.

M 6.208 Module: Safe Human-Robot-Collaboration [M-INFO-104877]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-INFO-109911	Safe Human-Robot-Collaboration	3 CR	Kurth

Competence Goal
You will get familiar with the various forms of human-robot collaboration (HRC) and their respective advantages. You will understand the requirements of the Machinery Directive and the relevant standards for the safety of HRC applications. Participants will be able to identify risks and to develop a safety concept for HRC systems.

Course objectives:

- Successful participants are familiar with all relevant aspects of human-robot collaboration, from the planning to the implementation of an HRC application as well as the requirements for safety.
- Successful participants understand the process of risk assessment, the importance of functional safety and predictable misuse.
- Successful participants will understand the different safety functions of robots and their use to reduce the risk to an acceptable residual risk and know to use complementary safety light curtains and laser scanners.
- The participants will know what has to be considered in designing a HRC system and can create a safety concept for this system and check it for completeness.

Content

- Introduction and fundamentals of Human-Robot Collaboration (HRC)
- Different forms of HRC and differentiation to full automation
- Practical examples from series applications
    - Advantages of HRC compared to full automation with robots
- Definition of safety
    - Machinery Directive / Standards
    - Declaration of incorporation / CE conformity
    - Safety Levels
    - Safety requirements in robotics
- Potential hazards in human-robot collaboration
    - bump and squeeze
    - Foreseeable misuse
    - Error in the application
- "Safe (?)" Robots
    - Requirements for collaborative operation according to ISO 10218-1
    - Overview of robots and their security concepts
    - Safely supervised robots
    - Gray technology / yellow technology in the robot controller
    - Safety functions based on position values and on force / torque values
- Safe HRC-Applications
    - Risk assessment
    - HRC cell layout
    - Design of HRC end effectors, peripherals
    - Use of safety features
    - Examples of industrial HRC-solutions
- From planning to the realization of HRC systems
    - HRC compliant engineering
    - Detailing of the HRC concept in the design phase
    - Programming and validation
    - Measurements demonstrating compliance with biomechanical limits
- Biomechanical limits
    - TS 15022
    - transient and quasi-static contact
    - body atlas with limits
- Safe sensor technology for safeguards
    - Basics
    - Laser scanners
    - Light curtains
    - Tactile sensors
    - Safe vision systems
    - Planning and design of safeguards

- Reaction time from the triggering event to the robot reaction

- Necessary safety distances for effectiveness of safeguards

- Safety in mobile robotics

M 6.209 Module: Satellite Communications [M-ETIT-105272]

Responsible: Prof. Dr.-Ing. Laurent Schmalen
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	2 terms	English	4	1

Mandatory			
T-ETIT-110672	Satellite Communications	3 CR	Schmalen

Competence Certificate
Oral exam approx. 20 minutes.

Prerequisites
Knowledge of basic engineering mathematics including probability theory and analysis, as well as basic knowledge of communications engineering.

Competence Goal
Students will be able to understand and apply the basics of satellite communications and navigation. They will be able to design and evaluate a satellite communication link and compute the achievable data rates over the link. They understand the key components of a satellite communication system, and get to distinguish the different types of satellite systems. Additionally, they know about existing satellite systems and novel ideas such as mega constellations

Content
The course covers the following contents:

- Introduction and Historical Notes
- Orbits and Geometry (including also constellations)
- Link BudgetsInformation Transmission Aspects
- Multiple Access and Multiplexing * Multi-Beam Satellite Systems
- Spacecraft Payload Aspects
- Network Aspects
- Overview of Existing Satellite Systems
- Overview of Future Satellite Systems
- Satellite Systems for Navigation

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Attendance lecture: 15 * 2 h = 30 h

Preparation / Postprocessing Lecture: 15 * 2 h = 30 h

Exam preparation and presence: 30 h Total: 90 h = 3 LP

Total: 90 h = 3 LP

Recommendation
Previous attendance of the lectures "Communication Engineering I" and "Probability Theory" is recommended. Knowledge from the lecture "Communications Engineering II" can be helpful, but is not necessary

M 6.210 Module: Scientific Computing for Engineers [M-MACH-105369]

Responsible: Dr. Daniel Weygand
Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-MACH-100532	Scientific Computing for Engineers	4 CR	Gumbsch, Weygand

Competence Certificate
written exam 90 minutes

Prerequisites
none

Competence Goal
The student can

- apply the programming language C++ for scientific computing in the field of materials science
- adapt programs for use on parallel platforms
- choose suitable numerical methods for the solution of differential equations.

Content
1. Introduction: why scientific computing
2. computer architectures
3. Introduction to Unix/Linux
4. Foundations of C++
* progamm organization
* data types, operator, control structures
* dynamic memory allocation
* functions
* class
* OpenMP parallelization
5. numeric /algorithms
* finite differences
* MD simulations: 2nd order differential equations
* algorithms for particle simulations
* solver for linear systems of eqns.

Annotation
The lecture can not be combined with the lecture "Application of advanced programming languages in mechanical engineering" (2182735).

Workload
egular attendance: 22,5 hours
Lab: 22,5 hours (optional)
self-study: 75 hours

Learning type
Tutorial

Literature

1. C++: Einführung und professionelle Programmierung; U. Breymann, Hanser Verlag München
2. C++ and object-oriented numeric computing for Scientists and Engineers, Daoqui Yang, Springer Verlag.
3. The C++ Programming Language, Bjarne Stroustrup, Addison-Wesley
4. Die C++ Standardbibliothek, S. Kuhlins und M. Schader, Springer Verlag
5. Numerical recipes in C++ / C / Fortran (90), Cambridge University Press
6. Numerische Mathematik, H.R. Schwarz, Teubner Stuttgart
7. Numerische Simulation in der Moleküldynamik, Griebel, Knapek, Zumbusch, Caglar, Springer Verlag

M 6.211 Module: Seminar Accessibility - Assistive Technologies for Visually Impaired Persons [M-INFO-102374]

Responsible: Prof. Dr.-Ing. Rainer Stiefelhagen
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	2

Mandatory			
T-INFO-104742	Seminar Accessibility - Assistive Technologies for Visually Impaired Persons	3 CR	Stiefelhagen

M 6.212 Module: Seminar Advanced Concepts for Flexible and Soft Optoelectronic Devices and Sensors [M-ETIT-106674]

Responsible: Prof. Dr. Gerardo Hernandez Sosa
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each term	1 term	English	4	1

Mandatory			
T-ETIT-113427	Seminar Advanced Concepts for Flexible and Soft Optoelectronic Devices and Sensors	3 CR	Hernandez Sosa

Competence Certificate
The examination consists of a written journal article and an oral presentation of the student's work, both given in English. The overall impression is rated.

Prerequisites
none

Competence Goal
At the end of the seminar, students will be able to independently familiarize themselves with new research topics, independently search and select relevant scientific literature and summarize the topic in the form of a concise journal-style article as well as an oral presentation. Through the critical evaluation and exposure to current scientific literature, the students will develop a deeper knowledge in the future directions in the research field of flexible and soft electronics. Furthermore, they will develop skills in scientific writing and communication in English language, which are key competences for their future academic and professional career.

Content
The seminar on "Seminar Advanced Concepts for Flexible and Soft Optoelectronic Devices and Sensors“ is for students curious in the latest research developments on devices, materials and the physics of novel optoelectronic devices. Discussed topics include but are not limited to: solution processable and printed electronics, flexible and stretchable electronics, wereable sensors, soft robotics, printed optics, biodegradable & sustainable electronics, 3D electronics, etc.

The seminar addresses master students from electrical engineering, physics, mechanical engineering, material science, KSOP and related MSc programs. During the seminar, the students will get the opportunity to familiarize themselves with state-of-the-art research from a selection of topics under the guidance of a mentor and discuss the topic during a presentation in the seminar. The students must attend the seminar regularly, independently present the research topic in a 30-min scientific talk and submit a short scientific review paper (3-5 pages) based on the scientific literature the presentation was based on.

Prof. Dr. Gerardo Hernandez Sosa and Prof. Dr. Jasmin Aghassi-Hagmann will select the topics and guide the discussion.

Module grade calculation
The module grade results of the assessment of the written paper and the oral presentation. Details will be given during the lecture.

Annotation
Attendance of at least 80% is compulsory during the seminar course. Compulsory attendance is necessary for actively contributing to the discussion of the topics presented by all students.

Workload
The workload includes (2 SWS):

- active participation in the preparation sessions and seminar lectures: 22,5 h
- preparation of the seminar presentation: 36 h
- preparation of the written journal article: 31,5 h

Total: 90 h = 3 LP

Recommendation
Basic knowledge in the field of conventional and/or organic (opto) electronic devices and sensors is helpful.

6.213 Module: Seminar Battery II [M-ETIT-105321]

Responsible: Dr.-Ing. Andre Weber
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each term	1 term	German/English	4	1

Mandatory			
T-ETIT-110801	Seminar Battery II	3 CR	Weber

Competence Certificate
The performance review takes the form of a written paper and a seminar presentation. The overall impression will be evaluated.

Prerequisites
none

Competence Goal
After completion of the seminar the students are able to work independently on an engineering problem in the field of batteries, to analyze the related literature and to present it in the form of a written paper and a presentation.

Content
The seminar "Batteries II" is primarily aimed at master students who are planning to write their master thesis in the field of batteries. In this seminar the participants will work on a scientific topic in the field of batteries. This usually includes a literature study, the compilation of the methods, procedures and results described in the publications as well as a critical evaluation of the same. In individual cases, next to a literature study more practical topics can be in focus.

The results are summarized in a seminar paper and presented in a lecture during the seminar. The grading is based on the written paper as well as the presentation t.

Module grade calculation
The assessment of the written paper and the seminar presentation will be included in the module grade. Further details will be given at the beginning of the course.

Workload
1. presence time seminar: 15 * 2 h = 30 h
2. preparation of seminar paper: 30 h
3. preparation of seminar presentation: 30 h

Total: 90 h = 3 LP

6.214 Module: Seminar Electrocatalysis [M-ETIT-105629]

Responsible: Prof. Dr.-Ing. Ulrike Krewer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each term	1 term	German	4	1

Mandatory			
T-ETIT-111256	Seminar Electrocatalysis	3 CR	Krewer

Prerequisites
none

M 6.215 Module: Seminar Embedded Systems [M-ETIT-100455]

Responsible: Prof. Dr.-Ing. Jürgen Becker
Prof. Dr.-Ing. Eric Sax
Prof. Dr. Wilhelm Stork

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each term	1 term	German	4	3

Mandatory			
T-ETIT-100753	Seminar Embedded Systems	4 CR	Becker, Sax, Stork

Competence Certificate
Success is assessed in the form of a written paper, reviews and a presentation. The overall impression is assessed.

Prerequisites
none

Competence Goal
Seminar participants can independently familiarize themselves with a given technical topic, identify all relevant aspects and summarize the results. In this context, students can identify relevant literature in terms of the research question, assess the strengths and weaknesses of existing approaches and methods, and formally evaluate other works according to specified criteria. They can also suggest new aspects in line with the research question. They can present the results of their work concisely in the form of a short text (approx. 6-page paper, usually written in English) and an approx. 15-minute presentation in words and pictures (slides).

Content
In the "Embedded Systems" seminar, students work on a given topic from the field of information processing through literature and internet research under the guidance of research assistants and then present it to the other seminar participants in a short text (approx. 6-page paper, usually written in English) and a 15-minute presentation in words and pictures (slides). The students give each other feedback as part of a peer review and thus experience a part of the scientific publication process.

Module grade calculation
The grading is based on the elaboration, the mutual review and the presentation.

Workload
The workload includes:

1. Independent familiarization with a topic: 50h
2. Writing a scientific article: 40h
3. Preparing a peer review: 10h
4. Preparing and giving a presentation: 20h

Total: 120h = 4 LP

6.216 Module: Seminar Fuel Cell II [M-ETIT-105322]

Responsible: Dr.-Ing. Andre Weber
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each term	1 term	German/English	4	1

Mandatory			
T-ETIT-110799	Seminar Fuel Cell II	3 CR	

Competence Certificate
The examination consists of a written paper and an oral presentation of the students work. The overall impression is rated.

Prerequisites
none

Competence Goal
After completing the seminar, the students are able to familiarize themselves independently with an engineering question in the field of fuel cells, analyze the associated literature and present it in the form of a written report and a presentation.

Content
The seminar “Fuel Cell Research Projects” is primarily aimed at students who are planning to carry out a scientific thesis in the fuel cell research area.
In this seminar the participants deal with scientific questions in the field of fuel cells. This includes a literature search, the compilation of the methods, processes and results described in the publications as well as a critical evaluation of the same.

The results are summarized in a seminar paper and presented in a lecture during the seminar. The written work and a lecture that has to be given during the event are included in the grading of the thesis.

Module grade calculation
The module grade results of the assessment of the written paper and the oral presentation. Details will be given during the lecture.

Workload
1. Presence seminar: 15 * 2 h = 30 h
2. Preparation of seminar paper and lecture: 30 h
3. Preparation of seminar lecture: 30 h

Total: 90 h = 3 LP

M 6.217 Module: Seminar New Components and Systems of Power Electronics [M-ETIT-100396]

Responsible: Prof. Dr.-Ing. Marc Hiller
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each term	1 term	German	4	2

Mandatory			
T-ETIT-100713	Seminar New Components and Systems of Power Electronics	4 CR	Hiller

Prerequisites
none

M 6.218 Module: Seminar Novel Concepts for Solar Energy Harvesting [M-ETIT-103447]

Responsible: Prof. Dr. Bryce Sydney Richards
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	2

Mandatory			
T-ETIT-108344	Seminar Novel Concepts for Solar Energy Harvesting	3 CR	Richards

Competence Certificate
The examination consists of a written journal article and an oral presentation of the student's work, both given in English. The overall impression is rated.

Prerequisites
none

Competence Goal
After completion of the seminar, students are able to independently familiarize themselves with a new research topic, recapitulate the corresponding literature and present the topic in the form of a review journal article as well as an oral overview presentation. Besides the exposure to new scientific research topics, the students will develope their know-how in scientific presentations and scientific writing in English which are key competences for their future (e.g. MSc thesis projects and research).

Content
We are offering an advanced seminar on „ Novel Concepts for Solar Energy Harvesting" for students curious in latest research topics on devices, materials and physics of next generation solar energy harvesting. The students will get the opportunity to familiarize themselves with a state-of-the-art research topic of their choice under the guidance of a mentor and present the topic during the seminar. The students must attend the seminar regularly, present the research topic in a 30-min scientific talk and submit a short scientific paper (3-5 pages). The seminar addresses master students from electrical engineering, physics, mechanical engineering, material science, KSOP and related MSc programs.

Module grade calculation
The module grade results of the assessment of the written paper and the oral presentation. Details will be given during the lecture.

Workload

1. participation in the seminar lectures: 22,5 h
2. preparation of the seminar presentation: 50 h
3. preparation of the journal article: 47,5 h

Recommendation
Good knowledge of semiconductor components/optoelectronics is desirable.

6.219 Module: Seminar on Applied Superconductivity [M-ETIT-105615]

Responsible: Prof. Dr. Tabea Arndt
Prof. Dr. Bernhard Holzapfel
Prof. Dr. Sebastian Kempf
Prof. Dr.-Ing. Mathias Noe

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	2

Mandatory			
T-ETIT-111243	Seminar on Applied Superconductivity	3 CR	Arndt, Holzapfel, Kempf, Noe

Competence Certificate
Elaboration of a scientific topic and presentation of a talk on the topic within the seminar of about 30min.

Competence Goal
Students are to familiarize themselves with an unknown scientific topic in the field of applied superconductivity. They independently prepare a presentation on the topic they have chosen and are able to present it to the general audience. In this role, the students will learn to clearly and didactyly communicate scientific topics and to lead a scientific discussion. As audience members, students are also enabled to recognize strengths and weaknesses of a presentation and to give constructive feedback to the person giving the presentation.

Content
In the seminar, students choose a current topic from the fields of

- Superconducting materials
- Superconducting magnet technology
- Superconducting power supply systems
- Superconducting detectors and sensors
- Superconducting Quantum Bits and Quantum Computing

and present this topic in a lecture to the other seminar participants.

Module grade calculation
The module grade corresponds to the grade of the oral examination.

Workload
For the successful completion of the module, a workload of approx. 90h is required. This is composed as follows:

1.) Attendance time in the seminar: 12*1.5h = 18h

2.) Preparation and follow-up of the seminar: 12*3h = 36h

3.) Preparation and execution of the presentation with handouts: 36h

Recommendation
None

M 6.220 Module: Seminar Radar and Communication Systems [M-ETIT-100428]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each term	1 term	English	4	1

Mandatory			
T-ETIT-100736	Seminar Radar and Communication Systems	4 CR	Zwick

Competence Certificate
The performance evaluation takes place by means of an overall examination according to § 4 Paragraph 2 No. 3 SPO-MA-2015, 2018 of the selected courses, the sum total of which fulfills the minimum requirement of course credits.

The examination takes place in the form of submission of a written report (paper) along with an oral presentation of the individual work.

Both are taken into account, while grading the examination performance. The overall impression will be evaluated.

Prerequisites
none

Competence Goal
The students are provided with an overview of a broad range of topics in the field of radio frequency engineering. You are in a position to work independently in the following areas: carrying out literature research, the art of holding lectures and presentations and writing research papers. You can work in a self-organized manner and acquire communicative, organizational and initial-level didactic skills. You are given the opportunity to work independently on a radio frequency engineering topic, to analyze the topic and present it in front of an expert audience.

Content
The seminar in particular offers the opportunity to learn and sharpen the skills of holding lectures and oral presentations, conducting literature research and writing research papers. Although these skills constitute a decisive qualification in the professional life, they are seldom promoted in other courses. The seminar provides a remedial action in this regard: each participant works independently on a topic (predominantly in english language) and presents it in front of an expert audience. In the final discussion, besides technical aspects, presentation style and written report are also taken into consideration.

Apart from presenting the topic, the required written report in LaTeX provides an excellent preparation for fulfilling the requirements of scientific and technical thesis works.

Module grade calculation
The course grade is calculated on the basis of the presentation as well as the written report. Both are taken into account for the performance evaluation. An assessment will be made based on the overall impression.

Annotation
Not offered in WiSe 24/25

Workload
Each credit point corresponds to approximately 25-30 hours of work (of the student). This is based on the average student who achieves an average performance. The workload includes:

Literature research: 40 h

Writing of the paper: 40 h

Presentation including preparation: 40 h

A total of 120 h = 4 LP

Recommendation
Knowledge of fundamentals of radio frequency engineering are helpful.

M 6.221 Module: Seminar Selected Topics in Communication [M-ETIT-100441]

Responsible: Dr.-Ing. Holger Jäkel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each term	1 term	German	4	1

Mandatory			
T-ETIT-100962	Seminar Selected Topics in Communications	4 CR	Jäkel

Prerequisites
none

6.222 Module: Seminar Sensors [M-ETIT-100380]

Responsible: Dr. Wolfgang Menesklou
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each term	1 term	German	4	1

Mandatory			
T-ETIT-100707	Seminar Sensors	3 CR	Menesklou

6.223 Module: Sensors [M-ETIT-100378]

Responsible: Dr. Wolfgang Menesklou
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	2

Mandatory			
T-ETIT-101911	Sensors	3 CR	Menesklou

6.224 Module: Signal Processing in Communications [M-ETIT-100443]

Responsible: Dr.-Ing. Holger Jäkel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German	4	2

Mandatory			
T-ETIT-100747	Signal Processing in Communications	4 CR	Jäkel

Prerequisites
none

M 6.225 Module: Signal Processing Lab [M-ETIT-106633]

Responsible: Prof. Dr.-Ing. Sander Wahls
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-113369	Signal Processing Lab	6 CR	Wahls

Competence Certificate
Success is assessed in the form of a written examination lasting 120 minutes.

Prerequisites
none

Competence Goal
After this module, students will have a sound basic knowledge of the main methods of signal processing as well as their areas of application, key parameters and the effects of parameter changes on the behavior of the methods. Students will be able to analyze given signal processing tasks in group work, develop solutions and document their results.

Content
The Digital Signal Processing practical course currently comprises eight experiments designed to familiarize students with the fundamentals of signal processing, in particular some selected measurement methods such as correlation measurement technology and modal analysis as well as Kalman filtering and the fundamentals of image processing. The focus of the experiments to be completed with various programs and devices is to teach students the practical aspects of modern signal processing.

Note: The lecturer reserves the right to include experiments other than those listed here in this practical course without prior notice.

Module grade calculation
The module grade is the grade of the written examination.

Annotation
A prerequisite for admission to the examination is the submission of protocols of all experiments. The quality of the protocols will be assessed; they must be acceptable for admission to the examination.

Attendance is compulsory during all practical sessions, including the introductory session. Admission to the examination will not be granted for even one unexcused absence.

Workload
The workload results from attending the introductory event (1.5 h), 8 experimental sessions of 4 h each. In addition, the preparation of the experiments is estimated at 8x4 h and the writing of the protocols as well as the follow-up work at 8x4 h. Preparing for the exam and attending it takes about 60 hours. This results in a total workload of approx. 160 hours.

Recommendation
Knowledge of the contents of the modules "Signals and Systems", "Measurement Technology" and "Methods of Signal Processing" is strongly recommended.

6.226 Module: Signal Processing Methods [M-ETIT-106899]

Responsible: Prof. Dr.-Ing. Sander Wahls
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Field of Specialization: Information and Communication Technology
Field of Specialization / Automation, Robotics, and Systems Engineering
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-113837	Signal Processing Methods	6 CR	Wahls

Competence Certificate
Written exam, approx. 120 minutes.

Prerequisites
none

Competence Goal
Students can

- choose appropriate estimation methods based on theoretical properties and practical considerations
- determine estimators for specific problems
- can weight the pros and cons of data decomposition methods; apply them to given problems; interpret the results
- understand the advantages and limitations of the considered time-frequency analysis methods
- interpret time-frequency representations
- choose appropriate analysis and synthesis windows/wavelets
- determine time-frequency transforms of given signals

Content
This module introduces students to advanced signal processing methods that are widely employed in engineering. The three main topic areas are

1. Parameter estimation
2. Decomposition of data into components and modes
3. Time-frequency analysis

The following topics are treated:

· Best linear unbiased estimator
· Maximum likelihood estimation
· General Bayesian estimators
· Linear Bayesian estimators
· Principal component analysis
· Independent component analysis
· Dynamic and empirical mode decomposition
· Hilbert spaces and frames
· Short-time Fourier transform
· Wavelets
· Analytic signals
· Wigner-Ville-Distribution
· Huang-Hilbert transform

Illustrating examples from diverse application areas are discussed.

Module grade calculation
The module grade is the grade of the written exam.

Workload
The workload includes:

1. attendance in lectures and tutorials: 15*4 h = 60 h
2. preparation / follow-up: 15*4 h = 60 h
3. preparation of and attendance in examination: 60 h

A total of 180 h = 6 CR

Recommendation
Familiarity with signals and systems (in particular, Fourier transforms) and probability theory at the Bachelor level is assumed.

M 6.227 Module: Signal Processing with Nonlinear Fourier Transforms and Koopman Operators [M-ETIT-106675]

Responsible: Prof. Dr.-Ing. Sander Wahls
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-113428	Signal Processing with Nonlinear Fourier Transforms and Koopman Operators	6 CR	Wahls

Competence Certificate
The examination in this module consists of programming assessments and a graded written examination of 120 minutes.

The programming assignments are either pass or fail. They must be passed during the lecture period for admission to the written examination.

Prerequisites
none

Competence Goal
Students

- understand the basic theory of linear operator on Hilbert spaces and can analyze simple operators analytically
- know the use cases for selected integrable partial differential equations (PDEs) and can apply them under non-ideal circumstances (small non-integrable terms)
- can determine the PDE corresponding to a given Lax-pair and check if the PDE is actually integrable (i.e. check if the Lax pair is “fake”)
- understand the theory of nonlinear Fourier analysis for selected PDEs and can compute nonlinear (inverse) Fourier transforms numerically and, in simple cases, analytically
- know and implement practical engineering applications of nonlinear Fourier transforms
- understand the theory of the Koopman operator including selected engineering applications
- compute Koopman spectra numerically using data-driven methods and use them in practical engineering applications

Content
This module introduces students to signal processing methods that rely on nonlinear Fourier transforms and Koopman operators. These methods allow us to transform large classes of nonlinear systems such that they essentially behave like linear systems. They can also be used to decompose signals driven by such systems into physically meaningful nonlinear wave components (for example, solitons).

While these methods originated in mathematical physics, there has been a growing interesting of exploiting their unique capabilities in engineering contexts. The goal of this module is to give engineering students a practical introduction to this area. It provides the necessary theoretical background, enables students to apply the methods in practice via computer assignments, and discusses recent research from the engineering literature.

The following topics will be discussed:

- Introduction to linear operators on Hilbert spaces
- Integrable model systems (Korteweg-de Vries equation, Nonlinear Schrödinger equation)
- Lax-integrable systems (representations of Lax pairs, fake Lax pairs, conserved quantities)
- Solution of integrable model systems using nonlinear Fourier transforms (inverse scattering method) and the unified transform method
- Physical interpretation of nonlinear Fourier spectra (in particular, solitons)
- Practical applications of nonlinear Fourier transforms
- Theoretical properties of Koopman operators
- Data-driven computation of Koopman operators (residual dynamic mode decomposition)
- Practical applications of Koopman operators

Module grade calculation
The module grade is the grade of the written exam.

Annotation
Some tutorial sessions will be classically devoted to solving pen and paper problems, but in others students will be working on their practical computer assignments. For the latter, students have to bring their own laptops with Matlab installed. The solutions of the computer assignments must be submitted by the provided deadlines, which are typically one week after the corresponding tutorial has taken place.

Workload
The workload includes:

1. attendance in lectures and tutorials: 15*4 h = 60 h
2. preparation / follow-up: 30*3 h = 60 h
3. finishing programming assignments: 30 h
4. preparation of and attendance in examination: 30 h

A total of 180 h = 6 CR

Recommendation
Familiarity with signals and systems at the Bachelor level (Fourier and Laplace transforms, linear systems, etc.) is assumed.

M 6.228 Module: Single-Crystal Growth – Crystal Growth Methods and Applications of Crystals for Electronic and Optical Components [M-ETIT-106597]

Responsible: Prof. Dr. Marc Eichhorn
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-113293	Single-Crystal Growth – Crystal Growth Methods and Applications of Crystals for Electronic and Optical Components	3 CR	Eichhorn

6.229 Module: Single-Photon Detectors [M-ETIT-101971]

Responsible: Dr. Konstantin Ilin
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-ETIT-108390	Single-Photon Detectors	4 CR	Ilin

Competence Certificate
Type of Examination: Oral exam
Duration of Examination: approx. 20 minutes

Prerequisites
none

Competence Goal
After completing the module, students will get basic knowledges on various physical mechanisms underlying optical response of the currently available detectors with the ultimate sensitivity – the single-photon detectors (SPDs) – thereby will be able to explain their functionality in details. The grasp of these knowledges enables students to critically analyze advantages and limitations of different types of SPDs and to make a decision on development of the detection system for particular applications.

Content
The students will get an overview of the modern types of single-photon detectors already widely used in applications and currently developing as well. Basics of the response mechanisms of the detectors and particular areas of their application will be considered as well as the main directions of development and optimization of new types of SPDs and detection systems. In particular the following topics will be addressed:

- Applications of single-photon detectors (SPD)
- Detection system and light-matter interaction
- Basic characteristics of SPDs and experimental methods of their determination
- Photoelectric effect: photomultiplier tubes (PMT); microchannel plate (MCP)
- Semiconducting detectors: photoresistor, PIN photodiode, avalanche photodiode (APD), single-photon avalanche diode (SPAD), visible light photon counter (VLPC), quantum dot field effect transistor (QD-FET)
- Superconducting detectors: transition edge sensor (TES), superconducting tunnel junction (STJ), superconducting nanowire single-photon detector (SNSPD)
- Hybrid detection system

Module grade calculation
The module grade is the grade of the oral exam.

Workload

1. Lecture presence time in winter semester– 18 h
2. Exercises presence time – 9 h
3. Pre- /Post-preparation on lectures/exercises- 36 h
4. Preparation to and examination – 57 h

M 6.230 Module: Software Engineering [M-ETIT-100450]

Responsible: Dr. Clemens Reichmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	3

Mandatory			
T-ETIT-108347	Software Engineering	3 CR	Reichmann

Prerequisites
none

M 6.231 Module: Solar Energy [M-ETIT-100524]

Responsible: Prof. Dr. Bryce Sydney Richards
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-100774	Solar Energy	6 CR	Richards

Competence Certificate
Type of Examination: written exam

Duration of Examination: 120 Minutes

Modality of Exam: One written exam at the end of each semester.

Prerequisites
Students not allowed to take either of the following modules in addition to this one: „Solarenergie“ (M-ETIT-100476) and „Photovoltaik“ (M-ETIT-100513).

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-ETIT-100513 - Photovoltaics must not have been started.

Competence Goal
The students:

• understand the basic working principle of pn-junction solar cells,

• learn about the different kinds of solar cells (crystalline and amorphous silicon, CIGS, Cadmium telluride, organic, dye-sensitized solar cells, etc.),

• get an overview over upcoming third-generation photovoltaic concepts,

• receive information on photovoltaic modules and module fabrication,

• develop an understanding of solar cell integration and feeding the electrical power to the grid,

• get insight into solar concentration and tandem solar cells for highly efficient energy conversion,

• compare photovoltaic energy harvesting with solar thermal technologies

• understand the environmental impact of solar energy technologies.

Die Studentinnen und Studenten können in englischer Fachsprache sehr gut kommunizieren.

Content
I. Introduction: The Sun

II. Semiconductor fundamentals

III. Solar cell working principle

IV. First Generation solar cells: silicon wafer based

V. Second Generation solar cells: thin films of amorphous silicon, copper indium gallium diselenide, cadmium telluride, organic photovoltaics and dye sensitized solar cells

V. Third Generation Photovoltaics: high-efficiency device concepts incl. tandem solar cells

VI. Modules and system integration

VII. Cell and module characterization techniques

VIII. Economics, energy pay-back time, environmental impact

IX. Other solar energy harvesting processes, incl. thermal and solar fuels

X. Excursion

Module grade calculation
The module grade is the grade of the written exam.

Workload
Total 180 h, thereof 60h contact hours (45h lecture, 15h problems class), and 120h homework and self-studies

Recommendation
Knowledge of optoelectronics is a prerequisite, e.g. M-ETIT-100480 – Optoelektronik.

Literature

P. Würfel: Physics of Solar Cells

V. Quaschning: Renewable Energy Systems

C. Honsberg and S. Bowden, PV Education CD-ROM and website, http://www.pveducation.org/pvcdrom

M 6.232 Module: Solar Thermal Energy Systems (Sp-STES) [M-MACH-101924]

Responsible: apl. Prof. Dr. Ron Dagan
Organisation: KIT Department of Mechanical Engineering

Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	3

Mandatory			
T-MACH-106493	Solar Thermal Energy Systems	4 CR	Dagan

Competence Certificate
oral exam of about 30 minutes

Prerequisites
None

Competence Goal
The students

get familiar with the global energy demand and the role of renewable energies

learn about improved designs for using efficiently the potential of solar energy

gain basic understanding of the main thermal hydraulic phenomena which support the work on future innovative applications

will be able to evaluate quantitatively various aspects of the thermal solar systems

Content
I. Introduction to solar energy: Energy resources, consumption and costs

II. The sun as an energy resource:

Structure of the sun, Black body radiation, solar constant, solar spectral distribution

Sun-Earth geometrical relationship

III. Passive and active solar thermal applications.

IV. Fundamentals of thermodynamics and heat transfer

V. Solar thermal systems - solar collector-types, concentrating collectors, solar towers. Heat losses and efficiency

VII. Energy storage

The course deals with fundamental aspects of solar energy. Starting from a global energy panorama the course deals with the sun as a thermal energy source. In this context, basic issues such as the sun's structure, blackbody radiation and solar–earth geometrical relationship are discussed. In the next part, the lectures cover passive and active thermal applications and review various solar collector types including concentrating collectors and solar towers and the concept of solar tracking. Further, the collector design parameters determination is elaborated, leading to improved efficiency. This topic is augmented by a review of the main laws of thermodynamics and relevant heat transfer mechanisms.

The course ends with an overview on energy storage concepts which enhance practically the benefits of solar thermal energy systems.

Workload
Total 90 h, hereof 30 h contact hours and 60 h homework and self-studies

Learning type
Lecture, tutorial

Literature
Foster, Ghassemi, cota,; Solar Energy

Duffie and Beckman; Solar engineering of thermal processes

Holman:, Heat transfer

Heinzel; script to solar thermal energy (in German)

M 6.233 Module: Source Coding Techniques [M-ETIT-105273]

Responsible: Prof. Dr.-Ing. Laurent Schmalen
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	2

Mandatory			
T-ETIT-110673	Source Coding Techniques	3 CR	Schmalen

Competence Certificate
Oral exam approx. 20 minutes.

Prerequisites
Knowledge of basic engineering mathematics including integral transformations and probability theory as well as basic knowledge of communications engineering.

Competence Goal
Students will be able to understand and apply the methods and tools of source coding. Students will learn a variety of tools for quantizing signals, transforming them into efficient storage and lossless compression methods. They continue to learn the theoretical limitations of source coding and can classify various practical methods based on the theoretical limits of their performance. With the help of numerical methods you can solve problems of source coding yourself.

Content
The course extends the topics covered in the lecture in Communication Technology I. The focus here is on methods that emerge when considering source coding. For this purpose, partially known techniques have to be extended, in some cases new methods have to be learned. Source coding is an indispensable tool in communications engineering, on the one hand to compactly represent and prepare multimedia signals for transmission and, on the other hand, to use storage capacity efficiently and economically. Source coding provides the direct link between the system user and the actual data transmission. The first part of the lecture deals with lossless source coding techniques, such as those used to reduce file size in popular zip format, but also more general lossless methods for the transmission of high quality signals. The second part is devoted to source coding of multimedia signals and, in particular, regards the source coding of audio and video signals. Different methods of quantization of multimedia signals are discussed and then shown how the quantized signals can be encoded in order to obtain as compact a representation as possible. In addition to predictive methods, transformation coding is also described. All of the methods are described in terms of their use in modern methods of source coding such as MP3, JPEG, H264. Many of the applications are illustrated with example implementations in software (python / MATLAB).

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Attendance lecture: 15 * 2 h = 30 h

Preparation / Postprocessing Lecture: 15 * 2 h = 30 h

Exam preparation and presence: 30 h

Total: 90 h = 3 LP

Recommendation
Previous visit to the lecture "Telecommunications I", "Probability Theory" and "Signals and Systems" is recommended. Knowledge from the lectures "Applied Information Theory" is helpful, but not necessary.

M 6.234 Module: Space-Born Microwave Radiometry - Advanced Methods and Applications [M-ETIT-100545]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-100810	Space-Born Microwave Radiometry-Advanced Methods and Applications	3 CR	Zwick

Competence Certificate
Success control is carried out as part of an overall oral examination (approx. 20 minutes) of the selected courses, with which the minimum requirement for CP is met.

Prerequisites
none

Competence Goal
The students have a basic knowledge of remote sensing with microwave radiometers on satellites. Applications of microwave radiometry on the ground, on airplanes and satellites. They are familiar with modern methods for the detection of anti-personnel mines, detection of hidden explosives and weapons. They can describe and evaluate the different types of radiometers and are able to apply the theoretical basics.

Content
The term microwave radiometry is the measurement of the natural thermal electromagnetic radiation in our natural environment. It has its origin in the atomic and molecular state transitions in matter at a physical temperature above 0K. It appears as unpolarized, random, broadband radiation (noise) and is dependent on the chemical / physical composition of the body to be imaged, its surface quality, frequency, polarization and the physical temperature.

Microwave radiometry is the logical continuation of photographic imaging in the optical range and radiometry in the infrared wavelength range.

The lecture is interdisciplinary and covers the entire system chain of imaging systems (radiation properties of the measurement object - propagation medium - sensor technology - data analysis) on the ground, on aircraft and satellites.

Module grade calculation
The module grade is the grade of the oral exam.

Workload
Each credit point corresponds to approximately 25-30 hours of work (of the student). This is based on the average student who achieves an average performance. The workload includes:

Attendance study time lecture / exercise: 30 h

Self-study time including exam preparation: 60 h

A total of 90 h = 3 LP

Recommendation
Knowledge of the basics of high frequency technology is helpful.

M 6.235 Module: Spaceborne Radar Remote Sensing [M-ETIT-103042]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	2

Mandatory			
T-ETIT-112857	Spaceborne Radar Remote Sensing - Exam	4 CR	Moreira, Prats
T-ETIT-112858	Spaceborne Radar Remote Sensing - Workshop	2 CR	Younis

Competence Certificate
The assessment takes place in the form of a written examination lasting 120 min. and in the form of reports (other types of examination). Those reports have to be submitted as part of the SAR computer workshop (approx. a total of five workshops). Details will be given during the lecture.

Prerequisites
"M-ETIT-100426 - Spaceborne SAR Remote Sensing" is not allowed to be started or to be completed.

Competence Goal
The students obtain a sound knowledge on the fundamentals, theory and applications of spaceborne radar systems. They understand the principle and function of synthetic aperture radars (SAR). They are able to explain the theory, techniques, algorithms for data processing and system concepts as well as to report on several application examples.

Content
The lecture is interdisciplinary and well suited for students interested in learning different aspects of the entire end-to-end system chain of spaceborne radar systems. Today, Synthetic Aperture Radar (SAR) systems are generating images of the Earth ´s surface with a resolution better than 1 meter. Due to their ability to produce high-resolution radar images independent of sunlight illumination and weather conditions, SAR systems have demonstrated their outstanding capabilities for numerous applications, ranging from environmental and climate monitoring, generation of three-dimensional maps, hazard and disaster monitoring as well as reconnaissance and security related applications. We have entered a new era of spaceborne and airborne SAR systems. New satellite systems like TerraSAR-X and TanDEM-X provide radar images with a resolution cell of more than a hundred times better than the one of conventional SAR systems. The lecture will cover all aspects of spaceborne radar systems including an overview of new technologies, applications and future developments.

Supporting the main lecture, exercise assignments are distributed to the students. The exercise solutions are presented and discussed in detail during lecture hall exercises. Further dedicated topics are explained to deepen the understanding of the main lecture contents.

The aim of the computer-workshop is to gain practical experience on radar systems using data and parameter simulations which are based on the evaluation of simplified models.

Module grade calculation
The module grade results of the assessment of the exam (4 LP) and the reports (2 LP).

Annotation
Further information can be found at the internet page of the IHE (https://s.kit.edu/ihe-srrs).

Workload
Each credit point corresponds to approximately 25-30 hours of work (of the student). This is based on the average student who achieves an average performance. Workload (for a lecture)

Attendance time in lectures, exercises: 60 h

Present study time computer exercise: 40 h

Self-study time including exam preparation: 80 h

A total of 180 h = 6 LP

Recommendation
Signal processing and radar fundamentals.

Literature
Lecture viewgraphs, reading material, and literature references can be found on ILIAS at https://s.kit.edu/srrs.

6.236 Module: Stochastic Information Processing (24113) [M-INFO-100829]

Responsible: Prof. Dr.-Ing. Uwe Hanebeck
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-INFO-101366	Stochastic Information Processing	6 CR	Hanebeck

M 6.237 Module: Student Innovation Lab [M-ETIT-105073]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Prof. Dr. Werner Nahm
Prof. Dr.-Ing. Eric Sax
Prof. Dr. Wilhelm Stork
Prof. Dr. Orestis Terzidis
Prof. Dr.-Ing. Thomas Zwick

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
15	Grade to a tenth	Each winter term	2 terms	English	4	2

Mandatory			
T-ETIT-110291	Innovation Lab	9 CR	Hohmann, Nahm, Sax, Stork, Zwick
T-WIWI-102864	Entrepreneurship	3 CR	Terzidis
T-WIWI-110166	SIL Entrepreneurship Project	3 CR	Terzidis

Competence Certificate
This module consists of an approx. 60-minute written exam on the contents of the Entrepreneurship lectures, as well as 5 other types of exams on the contents of the seminar Entrepreneurship and Innovation Lab in the form of term papers and presentations. All exams results are graded.

In addition, smaller, ungraded term papers are due during the course to monitor progress.

Prerequisites
An application is required to participate in this module. Information about the application: www.kit-student-innovation-lab.de/index.php/for-students/

Competence Goal
Personal competence

- Reflection faculty:
  The students are able to analyze, evaluate and develop an alternative for action for certain elements of action in social interaction
- Decision-making ability:
  The students are able to prepare a decision template in time and to provide the necessary arguments for alternative decisions and therefore are able to decide in time.
- Interdisciplinary teamwork
  Students are able to detect their limits of competence in one domain and to adjust to a the non-specialist domain. The students are able to detect a lack in competence and to compensate this lack via competences of other team members. The students are able to communicate their domain-specific knowledge and develop a basic understanding of other domains.
- Value-based action:
  The students are able to use selected psychological tools to determine their own values. They are able to match these values with team members and reflect if their offer fits these values.

Social competence

- Ability to cooperate:
  The students are able to analyze and judge their cooperative behavior in a group.
- Communication competence:
  The students are able to present their information in persuasive, focused and target group oriented way.
- Ability to deal with conflicts:
  The students are able to detect conflicts in advance, analyze them and name solution concepts.

Innovation and entrepreneurship competence

- Agile product development:
  The students are able to apply methods of agile product development e.g. Scrum.
- Methodical innovation retrieval:
  The students are able to conduct processes for user- and technology-centered innovation to develop sustainable value propositions for certain target groups (e.g. Design Thinking (DT), Technology Application Selection (TAS)- process).
- Orientation on management of new technology-based firms (NTBF):
  The students are able to name central concepts of intellectual property and legal structures. The students are able to name the most important tasks of entrepreneurial leadership. They are able to name the most common form of business modeling and to setup a business plan. The students know important approaches to establish an organization. The students are able to determine the ownership structure in an investment situation. The students are able to name marketing concepts and setup a business model.
- Generate investment readiness:
  The students are able to setup rudimentary revenue and cost plan. Furthermore, they are able to establish a project plan for a company in order to derive an investment plan. The students are able to present their business proposal to investors and develop empathy for the investors.
- Competence to develop a business model:
  The students are able to apply respective tools for business modeling e.g. Business Model Canvas. The students are able to develop and assess alternative business models.
- Risk handling:
  The students are able to name basic risks w.r.t. requirements, technical limitations and profitability. The students are able to apply methods of customer interaction for evaluation of requirements and willingness to pay. The students are able to setup a rudimentary competitors analyze. The students are able to name and identify risks and present potential reactions.

Systemic technical competence

- Problem solution competence:
  The students are able to analyze, assess and structurally solve a technical problem.
- Agile methodology of system development:
  The students are able to name and apply different system development processes.
- Validation in volatile environment:
  The students are able to conduct technical and economical validation under volatile constraints. For this, they are able to name the constraints and interpret the results of the validation.
- Functional decomposition:
  The students are able to identify, interpret and derive functional requirements from complex customer needs.
- Architecture development:
  The students are able to recognize coherences from the functional requirements and derive a suitable system architecture.

Content
This module strives to combine technical, social and personal competences from the technical and entrepreneurial domain. The objective is to prepare students as best as possible for entrepreneurial activity within or outside of an established organization. Our teaching methods are research-based with a practical orientation.

The lecture Entrepreneurship as the essential component offers the theoretical basis and provides insight in important theoretical concepts and empirical evidence. Currently released case studies and practical experiences of successful founders support the theoretical and empirical content. In order to run a company for the long term additional knowledge is important. That's why the lecture also teaches basic principles for opportunity recognition, business modeling, an introduction to entrepreneurial marketing and leadership. Customer-based design methods from the lean startup approach as well as methods of technology-centered innovation are presented. Future founders have to be able to develop and handle resources such as financial and human capital, infrastructure and intellectual property. Further aspects tackle the establishment of an organization and funding of the own project.

The knowledge taught in the lecture Entrepreneurship will be applied in an application-oriented seminar and the labs. Hence we use an action learning approach to extend the taught knowledge by practical skills and reflection capabilities. In an team of five, the students will experience their way from the ideation process to the final pitch in front of investors.

The students are able to choose between the following options concerning the labs:

- The Automation Innovation Lab offers drones as an innovation platform for cooperative swarm solutions.
- The Industry 4.0 Innovation Lab enables innovation in the context of the next industrial revolution via mobile robot platforms.
- In the Interconnected Intelligent Systems Lab innovations in the context of Assisted Living and Smart Housing are enabled by providing a rich assembly set of mobile robots, actuators and sensors.
- The Computer Vision for Health Lab offers a selection of state-of-the-art imaging devices and powerful computing hardware for innovative image-based applications for medicine and healthcare.

The module also presents methods of agile system development (Scrum) along with associated validation methods as well as methods for functional prototyping. Gate plans are used within the module to determine the progress of the project. Methods for single person work and teamwork are presented and applied. Additionally group-specific knowledge of the different roles of team members, solutions to conflict situations and interdisciplinary teams are presented.

Module grade calculation
The module grade consists of the written exam of the Lecture Entrepreneurship (40%), of the submissions and presentation of the Innovation Lab (40%) and of the submissions and presentation of the SIL Entrepreneurship Project (20%).

Annotation
Related courses:

Lecture Entrepreneurship
Seminar Entrepreneurship Project
Innovation Labs
Please note that the courses must be booked in parallel.

Related exams:

Written exams covering the content of lecture Entrepreneurship
Presentation of the Value Profile (seminar Entrepreneurship)
Submission of the Business Plan (seminar Entrepreneurship)
Submission of a Technical Report with requirements list and system architecture (Innovation Lab)
Submission of the reflection of the Gate Plans (Innovation Lab)
Presentation of the High-fidelity (Innovation Lab)

Workload
Lecture Entrepreneurship: 32h attendance time, 48h preparation and follow-up time, 10h preparation time for assessment

Seminar Entrepreneurship: 34h attendance time, 3h preparation and follow-up time, 53h preparation time for assessment.

Innovation Lab: 8h attendance time, 213h preparation and follow-up time, 49h preparation time for assessment.

This results in a total of 450 hours and a total of 15 LPs for both semesters (15*30/2 = 225).

Recommendation
It is recommended to attend the lecture Entrepreneurship at the same time as the seminar Entrepreneurship Project and the Innovation Lab in the winter semester.

M 6.238 Module: Superconducting Magnet Technology [M-ETIT-106684]

Responsible: Prof. Dr. Tabea Arndt
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-113440	Superconducting Magnet Technology	4 CR	Arndt

Competence Certificate
The examination takes place in form of an oral exam (abt. 30 minutes).

Two timeslots (weeks) for examination dates will be announced (usually near end of lecture period & end of semester)

Prerequisites
none

Competence Goal

- The students have a solid knowledge of architecture and design aspects of applications in magnets, windings and coils in power engineering.
- For the most important magnet applications the students can apply the state of the art, choose between options and can reflect the main benefits.
- The students have a clear understanding of opportunities, benefits and limitations of superconducting windings and magnets.
- The students are able to perform the required design calculations and to solve fundamental design questions independently.

Content
As the materials become increasingly mature and powerful, using superconductivity in a variety of applications of electrical engineering is of rising interest and benefit, too. This module is focuses on Superconducting Magnet Technology:

Windings, coils and magnets may be used as a device by itself (providing high magnetic fields e.g. in MRI, NMR, accelerators, industry magnets, etc.) or as components for Power Systems.

This section will cover the following aspects:

- Unique selling points of superconducting windings.
- Basic approaches and tools to design superconducting windings.
- Discussion of winding architectures
- Criteria to design the appropriate operating temperatures, materials, conductors, cooling technology for the electromagnetic purpose.
- Limits and opportunities when preparing and operating superconducting windings.
- Measures for safe operation of superconducting magnets.
- High-Field Magnets
- Magnets for Fusion Technology
- 3D topologies (e.g. in dipole magnets or motors/ generators)
- New options potentially offered by widespread use of hydrogen.
- New winding topologies

In the exercises, selected magnets will be designed and calculated analytically and with some computational tools (e.g. dipole magnets and compact, cryogen free HTS-magnets)

The lecturer may change the details of the content without further notice. Materials will be offered on ILIAS.

Module grade calculation
The module grade is the grade of the oral exam.

Workload

1. attendance in lectures and exercises: 15*3 h = 45 h
2. preparation / follow-up: 15*3 h = 45 h
3. preparation of and attendance in examination: 30 h

A total of 120 h = 4 CR

Recommendation
Having knowledge in “Superconducting Materials” is beneficial, but not mandatory.

M 6.239 Module: Superconducting Materials [M-ETIT-105521]

Responsible: Prof. Dr. Bernhard Holzapfel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each term	2 terms	English	4	2

Mandatory			
T-ETIT-111096	Superconducting Materials	6 CR	Holzapfel

Competence Certificate
The assessment of success takes place in the form of an oral examination lasting 40 minutes.

The oral examination includes the contents of Superconducting Materials Part I (offered every winter term) and Superconducting Materials Part II (offered every summer term).

Prerequisites
none

Competence Goal
The students have a good knowledge and can describe and compare the properties of different superconducting materials including those currently employed in energy and electronic applications (niobium-based superconductors, oxocuprates, MgB2) and also promising recently discovered ones (pnictides), including their synthesis methods.

Students have a thorough understanding of the synthesis variations of superconducting materials in bulk, thin film and wire form as well as the close relationship between microstructural properties of superconductors and their current carrying capabilities. They are able to select the appropriate superconducting materials for the different application scenarios of superconductors.

The students are able to talk about topic-related aspects in English using the technical terminology of the field of study.

Content
This lecture series gives an overview on the basic properties of the known different classes of superconducting materials as well as their synthesis routes in bulk, thin film and wire form. Special emphasis s given to the close interaction of micro- and nanoscale microstructural properties and the superconducting electrical transport properties, which are the key to all large scale applications in power and magnet technology.
The lecture series will cover basic properties of superconductors, superconducting elements, classical metallic superconducting alloys and compounds, high temperature superconductors, Fe-based superconductors and some other “exotic” superconductors, synthesis of superconducting films and wires, superconducting critical currents and pinning in type II superconductors as well an overview on the most prominent applications of superconductors in electronics, medicine and power application.
The obligatory practical work covers a few experiments regarding the synthesis and characterization of superconducting materials.
The lecturer reserves the right to alter the contents of the course without prior notification.
Course material will be available on ILIAS. Up-to-date information will be available via the ITEP- homepage prior to the beginning of the semester.

Module grade calculation
The module grade is the grade of the oral exam.

Annotation
WS: Superconducting Materials Part I

SoSe: Superconducting Materials Part II

Workload
A workload of approx. 186h is required for the successful completion of the module. This is composed as follows:

- Attendance time in lectures: 28*1.5h = 42h
- Preparation and follow-up of lectures: 28*3h = 84h
- Preparation for the exam: 60h

Recommendation
Knowledge of the basic course “Superconductivity for Engineers” is required

M 6.240 Module: Superconducting Nanowire Detectors [M-ETIT-105609]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	2

Mandatory			
T-ETIT-111236	Superconducting Nanowire Detectors	4 CR	Kempf

Competence Certificate
Oral Exam (20 min.)

Prerequisites
Module "M-ETIT-102332 - Thin films: technology, physics and applications" + Thin Films: Technology, Physics and Applications II must not be started.

Competence Goal
Students should be able to discuss interplay between growth conditions of thin films, physical and geometrical properties of nanostructure made of these films, and performance and suitable areas of application of detectors of radiation based on interaction of these nanostructures with electromagnetic power. The knowledge obtained by students should provide a theoretical basis for the most important steps in development of thin film nanoelectronic devices.

Content
Students will get practically oriented information about technology of thin films including different methods of deposition of thin films like magnetron sputtering, thermal evaporation, pulsed laser ablation, about basics of vacuum technology, and about mechanisms of growth of thin films of different materials at different conditions.

Patterning methods (photo- and e-beam lithography, reactive ion etching, ion milling, and lift-off techniques) suitable for nanometer scale features of electronic devices will be considered in details.

Experimental methods of characterization of material, geometrical, optical, physical, superconducting, electron and phonon properties of thin films, nanostructures made of these films, and devices based on these nanostructures will be discussed.

Consideration of technology and physics of thin film structures will be done on example of development of three types of fast and sensitive detectors of electro-magnetic radiation for applications in optical and THz spectral ranges: superconducting nanowire single-photon detector, hot-electron bolometer, and YBCO ps-fast detector of synchrotron emission. Dependence of detector's performance on their fabrication condition will be analyzed in frame of physical models which describe response mechanisms of the detectors to absorbed radiation.

Practical actualization of the knowledge is possible in frame of Praktikum Nanoelektronik (LVN 23669).

Module grade calculation
The module grade is the grade of the oral exam.

Workload
The workload in hours is broken down below:

1. Attendance time in lectures in the winter semester 15*3h = 45h
2. Preparation / follow-up of the same 15*3h = 45h
3. Exam preparation and attendance in the same 30h

Recommendation
Previous participation on Module "Physics, Technology and Applications of thin films " is recommanded.

M 6.241 Module: Superconducting Power Systems [M-ETIT-106683]

Responsible: Prof. Dr.-Ing. Mathias Noe
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-113439	Superconducting Power Systems	4 CR	Noe

Competence Certificate
The examination takes place in form of an oral exam (abt. 45 minutes).

Prerequisites
none

Competence Goal

- The students have a solid knowledge of architecture and design aspects of applications in windings and energy technology devices.
- For the most important power system applications the students can apply the state of the art and can reflect the main benefits.
- The students have a clear understanding of opportunities, benefits and limitations of superconducting components and devices.
- The students are able to perform the required design calculations and to solve fundamental design questions independently.

Content
As the materials become increasingly mature and powerful, using superconductivity in a variety of applications of electrical engineering is of rising interest and benefit, too. This module focuses on Superconducting Power Systems.

It will provide an overview of the state of the art, will give an insight into the basic setup, the design, the characteristic parameters and the specific operation behaviour of the following applications:

· Power Transmission Cables and Lines
· Motors and Generators
· Transformers
· Fault Current Limiters
· Magnetic Energy Storage
· Basics of Cryo Technology

For each application a design example is shown and the focus is given on the conceptual design of each application.

The lecturers may change the details of the content without further announcement.
Materials will be offered on ILIAS.

Module grade calculation
The module grade is the grade of the oral exam.

Workload

1. attendance in lectures and exercises: 15*3 h = 45 h
2. preparation / follow-up: 15*3 h = 45 h
3. preparation of and attendance in examination: 30 h

A total of 120 h = 4 CR

Recommendation
Having knowledge in „Superconducting Materials“ is beneficial.

Successful participation in „Superconductivity for Engineers“

M 6.242 Module: Superconductivity for Engineers [M-ETIT-105611]

Responsible: Prof. Dr. Bernhard Holzapfel
Prof. Dr. Sebastian Kempf

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Focus Area)
Field of Specialization / Electrical Power Systems and Electromobility (Fundamentals)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-ETIT-111239	Superconductivity for Engineers	5 CR	Holzapfel, Kempf

Competence Certificate
The assessment of success takes place in the form of a written examination lasting 120min. The grade corresponds to the result of the written examination.

Prerequisites
none

Competence Goal
Students know the physical fundamentals of superconductivity and can place various theoretical and practical aspects of superconductivity in the overall context. They understand the principles behind specific applications of superconductivity and are able to communicate with experts in the field.

Content
Superconductivity is one of the most fascinating and astonishing effects in solid state physics. It plays technologically an important role in many modern, scientific, medical and industrial applications. It establishes, for example, the basis of realizing high field electromagnets to be used in magnetic resonance imaging systems in healthcare or for guiding charged particle in modern particle accelerators such as the LHC. Moreover, it allows to build state-of-the-art energy systems as well as sensing devices such as magnetic field sensors or energy-dispersive single particle. In addition, it is conceivable that superconductivity will be utilized in near future for energy and traffic engineering applications, e.g. for dissipationless power transmission over large distances or high-speed trains connecting major cities.

Within this context, this module gives a comprehensive introduction in the basics of superconductivity paving the way for the discussion of state-of-the-art applications of superconductivity. In particular, the module will cover the following topics:

- Historical remarks
- Overview of superconducting materials and applications of superconductivity
- Reminder of normal metals: free electron gas, Drude and Sommerfeld model, electrical and thermal properties, band structure
- Phenomena of superconductivity: zero electrical dc resistance, Meissner Ochsenfeld effect
- Thermodynamics and thermal properties of superconductors
- Phenomenological theories of superconductors: Two-fluid model, London theory, Pippard theory, Ginzburg-Landau theory
- Microscopic theory of conventional superconductors
- Type-I and type-II superconductivity
- Magnetic properties of type-I and type-II superconductors
- Irreversible magnetic properties, Bean model
- AC losses
- Electrical and thermal stabilization
- Energy gap and quasiparticle tunneling
- Unconventional superconductors
- High-frequency electrodynamics of superconductors
- Macroscopic quantum effects
- Overview of applications of superconductivity

The tutorial is closely connected to the lecture and deepens important aspects from the field of superconductivity. Using exercises, important theories and effects as well as the realization of applications of superconductivity is discussed.

Module grade calculation
The module grade is the grade of the written examination.

Annotation
Will be changed to 6 CR in winter term 25/26.

Workload
A workload of approx. 149h is required for the successful completion of the module. This is composed as follows:

- Attendance time in lectures and exercises: 12*1.5h + 6*1.5h = 27h
- Preparation and follow-up of lectures: 12*3h = 36h
- Preparation and follow-up of tutorials: 6*6h = 36h
- Preparation for the exam: 50h

Recommendation
None

M 6.243 Module: System Integration and Communication Structures in Industry 4.0 and IoT [M-ETIT-106026]

Responsible: Prof. Dr.-Ing. Jürgen Becker
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-112212	System Integration and Communication Structures in Industry 4.0 and IoT	3 CR	Becker

Prerequisites
none

M 6.244 Module: System-on-Chip Laboratory [M-ETIT-100451]

Responsible: Prof. Dr.-Ing. Jürgen Becker
Prof. Dr. Ivan Peric

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Field of Specialization / Microelectronics, Photonics, and Quantum Technologies (Lab Course)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100798	System-on-Chip Laboratory	6 CR	Becker, Peric

Competence Certificate
Other types of examinations

Prerequisites
none

Competence Goal
Students can reproduce basic knowledge of digital and analog circuit design and hardware-related software programming. In practice, students are able to apply these methods in the following areas using a current system-on-chip architecture:

• Design of a system architecture for mixed-signal systems

• Simulation of the designed digital and analog circuits

• Debugging the implementations at the simulation and implementation level

• Verification of the overall system developed through test benches

In addition, they can apply the hardware / software code design approach and can evaluate implementation targets based on the given requirements (FPGA and ASIC).

Content
In the System-on-Chip Laboratory, a fully-fledged mixed-signal hardware architecture for audio playback based on a system-on-chip (SoC) is developed.

The system design includes the creation of necessary sub-components, their integration into an overall system, and the simulation and verification of the individual components and the overall system. A prototype is implemented and tested on an FPGA basis. The integration is then prepared for a possible ASIC production. Analog circuits are also considered and designed to build an audio amplifier.

Module grade calculation
The grade formation results from the combination of the processing of the exercise sheets, the evaluations during the internship and a final presentation including discussion of the results developed in the project.

Workload
1. Presence time in laboratory appointments: 15 * 4 = 60 hours

2. Preparation / post-processing: 15 * 4 = 60 hours

3. Demonstration and integration tests: 3 * 3 = 9 hours

4. Preparation of the final presentation: 15 hours

Recommendation

- Knowledge of Verilog Hardware Description Language, e.g. from Digital Circuit Design
- Knowledge in the design of analog circuits (amplifier circuits, stability considerations), e.g. from the Analog Circuit Design
- Knowledge of VHDL design, e.g. from Hardware Modeling and Simulation
- Knowledge of simulation of digital circuits, e.g. from Hardware Modeling and Simulation
- Knowledge of hardware design processes and algorithms, e.g. from Hardware Synthesis and Optimisation

M 6.245 Module: Systems and Software Engineering [M-ETIT-100537]

Responsible: Prof. Dr.-Ing. Eric Sax
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Field of Specialization / Automation, Robotics, and Systems Engineering
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-ETIT-100675	Systems and Software Engineering	5 CR	Sax

Competence Certificate
Written exam, approximately 90 minutes.

Students are given the opportunity to earn a grade bonus through separate task assignments. If the grade of the written exam is between 4.0 and 1.3, the bonus improves the grade by a maximum of one grade level (0.3 or 0.4). The exact criteria for awarding a bonus will be announced at the beginning of the lecture. Bonus points do not expire and remain valid for exams taken at a later date.

Prerequisites
none

Competence Goal
• Students are able to analyse and explain the functional principles and applications of embedded systems.

• Students are able to evaluate and apply maturity models as well as Software Development Life Cycle models including the waterfall model, V-model, prototyping model, agile models, and DevOps.

• Students are able to apply various creativity techniques to develop innovative solutions to problems. They will be able to derive and analyse requirements.

• Students are familiar with diagram formats software modelling languages; they can evaluate and create these based on problem descriptions of an application area. They will be able to create and evaluate functional, data-oriented, algorithmic, state-oriented, and object-oriented views.

• Students are able to understand and apply various aspects of the realization of embedded systems. They will be able to consider implementation alternatives: hardware, co-design and scheduling aspects.

• Students are familiar with the various testing phases in a project and can explain them. They can assess the reliability of a system and understand the concept of functional safety.

Content
The focus of the course is on processes and methods for the design of systems composed of electrical, electronic and electronically programmable systems that contain software, hardware and mechanical components. The desired competencies of the course include the knowledge and goal-oriented use of modeling techniques, design processes, description and representation tools as well as specification languages that correspond to the current state of the art.

Module grade calculation
The grade is determined by the written exam and the bonus points.

Annotation
Will be changed to 6 CR in winter term 25/26.

Workload
For each Credit Point (CP), 30h of work is scheduled. The resulting 150h are distributed as follows:

- 15 weeks of 1.5h attendance in lecture and 2h preparation and follow-up per week = 52.5h
- 15 weeks of 1.5h attendance in each exercise and at least 2h preparation (includes processing of exercise sheets and the processing of tasks for the acquisition of bonus points) per week = 52.5h
- Preparation for the exam = 45h

Recommendation

Knowledge in Digital Technology and Information and Automation Technology (e.g. module M-ETIT-102102 and M-ETIT-106336)

M 6.246 Module: Systems Engineering for Automotive Electronics [M-ETIT-100462]

Responsible: Hon.-Prof. Dr. Jürgen Bortolazzi
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-100677	Systems Engineering for Automotive Electronics	4 CR	Bortolazzi

Prerequisites
none

M 6.247 Module: Team Project: Sensors and Electronics [M-ETIT-105465]

Responsible: Prof. Dr.-Ing. Ahmet Cagri Ulusoy
Prof. Dr.-Ing. Thomas Zwick

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	pass/fail	Each term	1 term	German	4	1

Mandatory			
T-ETIT-111007	Team Project: Sensors and Electronics	3 CR	Ulusoy, Zwick

Competence Certificate
Final Design Report

Prerequisites
An application is required to participate in this module. Information about the application: https://www.ihe.kit.edu/VorlesungenWS_4850.php

Competence Goal

- Students independently expand their knowledge in a selected field of sensors and electronics beyond lecture contents
- Students will go through multiple phases from conceptual design to measurement and thereby gain practical experience
- Students are able to respect practical limits when applying theoretical knowledge
- Students can consider available measurement equipment in their design process
- Students are able to work in a team and organize a project independently and under their own responsibility

Content
Students will develop a system or a component in the field of sensors and electronics. The project's content has to go beyond the content of a single lecture or require the combination of multiple lectures. It has to be connected to general challenges or problems in research. On top of the theoretical aspects students will have to plan and execute their project's realization. Manufacturing tolerances/limits and available measurement equipment have to be respected. This module can be combined with an international student design competition.

Module grade calculation
No Grade. Only pass or fail.

Workload
A total of 90 hours (per Student) is estimated for the completion of this module.

1. Planning and conceptual design: 10h
2. Simulation & Design: 50h
3. Assembly, Verification, Measurement: 15h
4. Final report: 15h

Recommendation
Lectures at the Institute for Radio Frequency Engineering and Electronics (IHE)

6.248 Module: Technical Acoustic [M-ETIT-101835]

Responsible: Dr. Nicole Ruiter
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-104579	Technical Acoustic	3 CR	Ruiter

Competence Certificate
Success control is carried out as part of an overall oral examination (approx. 20 minutes) of the selected courses, with which the minimum requirement for CP is met.

Prerequisites
none

Competence Goal
The students understand the basics of acoustics and their technical applications and can understand the basic technical implementation.

Content
The lecture deals with the basics of sound and sound propagation. In addition to sound generation, the measurement and analysis methods for sound, the perception of sound in humans and is also discussed. Selected applications and their technical implementation are presented.

Module grade calculation
The module grade is the grade of the oral exam.

Workload
The workload includes:

Attendance time in lectures (2 h 15 appointments each) = 30 h

Self-study (3 h 15 appointments each) = 45 h

Preparation / post-processing = 20 h

Total effort approx. 95 hours = 3 LP

M 6.249 Module: Technical Optics [M-ETIT-100538]

Responsible: Prof. Dr. Cornelius Neumann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100804	Technical Optics	5 CR	Neumann

Prerequisites
none

M 6.250 Module: Telematics (24128) [M-INFO-100801]

Responsible: Prof. Dr. Martina Zitterbart
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German/English	4	1

Mandatory			
T-INFO-101338	Telematics	6 CR	Zitterbart

Competence Certificate
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
Students

- master protocols, architectures, and methods and algorithms that are used on the Internet for routing and for establishing a reliable end-to-end connection, as well as various media allocation procedures in local networks.
- have an understanding of the systems and the problems that appear in a global, dynamic network as well as the mechanisms used to remedy them.
- are familiar with current developments such as SDN and data center networking.
- know methods to manage and administrate networks.

Students master the basic protocol mechanisms for establishing reliable end-to-end communication. Students have detailed knowledge of the mechanisms used in TCP for congestion and flow control and can discuss the issue of fairness with multiple parallel transport streams. Students can analytically determine the performance of transport protocols and know methods that fulfill special requirements of TCP, such as high data rates and short latencies. Students are familiar with current topics such as problems introduced by utilization of middle boxes in the Internet, the use of TCP in data centers and multipath TCP. Students can use transport protocols in practice.

Students know the functions of routers in the Internet and can reproduce and apply common routing algorithms. Students can reproduce the architecture of a router and know different approaches to buffer placement as well as their advantages and disadvantages.

Students understand the distinction of routing protocols into interior and exterior gateway protocols and have detailed knowledge of the functionality and properties of common protocols such as RIP, OSPF and BGP. The students are familiar with current topics such as SDN.

Students know the function of media allocation and can classify and analytically evaluate media allocation processes. Students have in-depth knowledge of Ethernet and are familiar with various Ethernet forms and their differences, especially current developments such as real-time Ethernet and data center Ethernet. Students can reproduce and apply the spanning tree protocol.
Students can reproduce the technical characteristics of DSL. Students are familiar with the concept of label switching and can compare existing approaches such as MPLS.

Content

- Introduction
- End-to-end data transport
- Routing protocols and architectures
- Media allocation
- Bridges
- Data transmission
- Further selected examples
- Network management

Workload
Lecture with 3 SWS plus follow-up/exam preparation, 6 CP.

6 CP corresponds to approx. 180 working hours, of which

approx. 60 hours lecture attendance

approx. 60 hours preparation/follow-up work

approx. 60 hours exam preparation

M 6.251 Module: Test of Embedded Systems in Industrial Contexts [M-ETIT-100546]

Responsible: Prof. Dr.-Ing. Eric Sax
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100811	Test of Embedded Systems in Industrial Contexts	4 CR	Sax

Prerequisites
none

M 6.252 Module: The Energy Transition of the Electrical Transmission Grid [M-ETIT-105618]

Responsible: Prof. Dr.-Ing. Thomas Leibfried
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-111248	The Energy Transition of the Electrical Transmission grid	3 CR	Leibfried

Prerequisites
none

M 6.253 Module: Theoretical Foundations of Cryptography [M-INFO-105584]

Responsible: Prof. Dr. Jörn Müller-Quade
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-INFO-111199	Theoretical Foundations of Cryptography	6 CR	Müller-Quade

M 6.254 Module: Thermal Solar Energy [M-MACH-102388]

Responsible: apl. Prof. Dr. Ron Dagan
Organisation: KIT Department of Mechanical Engineering

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-MACH-105225	Thermal Solar Energy	4 CR	Dagan

Competence Certificate
A performance assessment is obligatory; oral exam about 30 minutes

Prerequisites
none

Competence Goal
Based on the elaboration of the basic physics knowledge of the solar irradiation, heat radiation, optics and thermal-hydraulics, the student will be able to

- select solar thermal components such as mirrors, glasses, selective absorbers and insulation materials and their manufacturing processes and to calculate and assess their performance,
- identify different collector types and to indicate their potential field of application,
- characterize the entire solar thermal collector system with respect to its performance and derive from the collector characteristics its suitability for different types of use,
- embed collectors into a technical overall system for heat (household, process heat, heat storage networks) or electricity generation (power plant), to calculate the system efficiency and independently develop the basics of its optimization.
- identify adequate thermal storage types for the temporal separation of generation and consumption, to dimension them appropriately and to integrate them into a system concept,
- evaluate solar thermal systems in their entirety (capacity, estimation of system dynamics, response behavior, efficiency) and know options for integration into networks (heat, cold, electricity).

Content
Fundamentals of thermal solar energy from solar irradiation (influence of time and place, modifications in the atmosphere) and their implementation in a collector to integration into a technical overall system. In detail:

1. introduction to the energy demand and evaluation of the application potential of solar thermal energy.

2. primary energy source SUN: Sun, solar constant, solar radiation (scattering, absorption in the atmosphere, direct-diffuse radiation, angular influences, radiation balance).

3. solar collectors: basic design of a collector, basics of determining the efficiency, significance of concentration and its limitations, solar thermal collector types (designs, efficiency, system technology).

4. passive mechanisms of solar thermal energy: heat conduction in solids and gases, radiation heat transport in transparent and opaque bodies Design requirements and physical principles of solar thermal glasses, mirrors and selective absorbers. Goal oriented selection of materials and manufacturing processes.

5. momentum and heat transport: basic equations of single- and multi-phase transport, basic ideas of local and system engineering calculation methods, stability limits.

<u>Optional</u>

6. solar thermal low-temperature systems: collector variants, methods for system simulation, planning and dimensioning of systems, system-related system design and stagnation scenarios and their handling.

7. solar thermal high-temperature systems: solar thermal power plants (classification of system components, loss mechanisms, upwind power plants), coupling of collector with energy generation process.

<u>At the end</u>:

8. Thermal energy storage: Explanation of terms (energy contents, storage forms and materials, potentials ...), storage concepts (system structure, design ratio), system integration.

9. Solar air conditioning: Determination of cooling capacity, indoor climate, solar cooling methods and evaluation of air conditioning.

Workload
regular lecture attendance: 30 h
self-study: 60 h (incl. supplementary searches)

exam preparation 30 h

Recommendation
desirable are reliable knowledge in physics in optics and thermodynamics

Basics in heat and mass transfer, material science, energy technology and fluid mechanics

Learning type
Präsentation complemented by printouts

Literature
supply of lecture material in printed and electronic form

Stieglitz & Heinzel; Thermische Solarenergie -Grundlagen-Technologie- Anwendungen. Springer Vieweg Verlag. 711 Seiten. ISBN 978-3-642-29474-7

6.255 Module: Ultrasound Imaging [M-ETIT-100560]

Responsible: Dr. Nicole Ruiter
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100822	Ultrasound Imaging	3 CR	Ruiter

Prerequisites
none

M 6.256 Module: Universal Composability in Cryptography [M-INFO-105783]

Responsible: Prof. Dr. Jörn Müller-Quade
Organisation: KIT Department of Informatics
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-INFO-111584	Universal Composability in Cryptography	3 CR	Müller-Quade

M 6.257 Module: Vacuum Technology [M-CIWVT-104478]

Responsible: Dr.-Ing. Thomas Giegerich
Organisation: KIT Department of Chemical and Process Engineering
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-CIWVT-109154	Vacuum Technology	6 CR	Giegerich

Competence Certificate
The examination is an oral examination with a duration of 20 about minutes (section 4 subsection 2 number 2 SPO).

The grade of the oral examination is the module grade.

Prerequisites
None

Competence Goal
Students will be able to explain basic physical relationships in vacuum science. Building on this, they can design a complex vacuum system correctly and in accordance with specifications.

Content
Basics; vacuum pumps; practical vacuum limits; outgassing and its minimization; cleanliness requirements; vacuum instrumentation; total pressure measurement; residual gas analysis; leak detection; rarefied gas flow; design of vacuum systems; technical specifications; quality in vacuum; examples for large vacuum systems; industrial applications in the process industry.

Module grade calculation
The grade of the oral examination is the module grade.

Workload

- Attendance time (Lecture): 60 h
- Homework: 80 h
- Exam Preparation: 40 h

Learning type
22033 – Übung zu Vakuumtechnik

22034 – Vakuumtechnik

Literature
K. Jousten (Ed.) - Wutz Handbuch Vakuumtechnik, 11. Auflage, Springer, 2013.

M 6.258 Module: Verified Numerical Methods [M-ETIT-104493]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-109184	Verified Numerical Methods	4 CR	Hohmann

6.259 Module: Visual Perception in the Automobile [M-ETIT-100497]

Responsible: Prof. Dr. Cornelius Neumann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100777	Visual Perception in the Automobile	3 CR	Neumann

Prerequisites
none

M 6.260 Module: Water – Energy – Environment Nexus in a Circular Economy: Research Proposal Preparation [M-CIWVT-106680]

Responsible: Prof. Dr. Andrea Iris Schäfer
Organisation: KIT Department of Chemical and Process Engineering
Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-CIWVT-113433	Water – Energy – Environment Nexus in a Circular Economy: Research Proposal Preparation	5 CR	

Competence Certificate
The Learning control is an examination of another type:
Research proposal of 10 pages and an oral presentation of 10 minutes (individual work). The grade will be a composite of the proposal (submission in week 13 before class) and oral & poster presentation (all day workshop with researcher participation).

Competence Goal
The goal of this course is to get an overview of current challenges in the circular economy focused on the water – energy – environment nexus. Based on individual student interest a topic will be identified and a research plan developed encompassing a thorough background research to establish the state-of-the-art, identification of a specific research problem and research questions suitable to solve this problem. Concepts of novelty and excellence will be explored in an international context. Following the individual topic choice, the research proposal will be developed individually in a tutor group (divided into water, energy, environment) while lectures on required skills will accompany this process. As an outlook beyond this course, criteria to consider when looking for research careers such as applying for funding/scholarships, considering choices in research environment and supervision, performance indicators in research and university rankings will be introduced to enable informed decisions. The proposal will be communicated in writing, as a brief presentation and as a poster, which equips students brilliantly not only for a masters thesis but also a future research publication or a PhD.

Content
In a time of limiting resources, climate change and ever increasing demand for resources the concept of a circular economy is inevitable to create a more sustainable utilization of our key resources, water, energy and ‘environment’. Concepts of zero liquid discharge, water reuse, carbon net zero, resource recovery and environmental pollution reduction are all part of this concept where where waste is returned to use. The water – energy – environment nexus is the particular focus of ths course. Global water issues, water and wastewater treatment, desalination, water reuse, micropollutants, decentralized systems, water & sanitation in international development, renewable energies, environmental pollution, climate change, resource recovery – and many more topics will inspire future research.

Module grade calculation
The module grade is the grade of the examination of another type.

Workload

- Contact time: lectures and tutorials 60 hrs (4 SWS)
- Group and self study: 50 hrs
- Preparation of assessments and participation at the group presentations (one full day): 30 hrs

M 6.261 Module: Wearable Robotic Technologies [M-INFO-103294]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Prof. Dr.-Ing. Michael Beigl

Organisation: KIT Department of Informatics

Part of: Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	3

Mandatory			
T-INFO-106557	Wearable Robotic Technologies	4 CR	Asfour, Beigl

Competence Certificate
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
The student has received fundamental knowledge about wearable robotic technologies and understands the requirements for the design, the interface to the human body and the control of wearable robots. He/she is able to describe methods for modelling the human neuromusculoskeletal system, the mechatronic design, fabrication and composition of interfaces to the human body. The student understands the symbiotic human–machine interaction as a core topic of Anthropomatics and has knowledge of state-of-the-art examples of exoskeletons, orthoses and prostheses.

Content
The lecture provides an overview of wearable robot technologies (exoskeletons, prostheses and ortheses) and their potentials. It starts with the basics of wearable robotics and introduces different approaches to the design of wearable robots and their related actuator and sensor technology. The lecture focuses on modeling the neuromusculoskeletal system of the human body, the interfaces of wearable robots to the human body and the physical and cognitive human-robot interaction for tightly-coupled hybrid human-robot systems. Examples of current research and various applications of lower, upper and full body exoskeletons as well as prostheses are presented.

Workload
Lecture with 2 SWS, 4 LP
4 LP corresponds to 120 hours, including
15 * 2 = 30 hours attendance time
15 * 3 = 45 self-study
45 hours preparation for the exam

Recommendation
Attendance of the lecture Mechano-Informatics in Robotics is recommended.

6.262 Module: Workshop Finite Element Method in Electromagnetics [M-ETIT-100555]

Responsible: Prof. Dr. Martin Doppelbauer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Field of Specialization / Electrical Power Systems and Electromobility (Focus Area)
Electives

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100818	Workshop Finite Element Method in Electromagnetics	3 CR	Doppelbauer

Prerequisites
none

7 Courses

T 7.1 Course: Adaptive Optics [T-ETIT-107644]

Responsible: Dr. Szymon Gladysz
Prof. Dr. Ulrich Lemmer

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: M-ETIT-103802 - Adaptive Optics

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2313724	Adaptive Optics	2 SWS	Lecture / 🗣	Gladysz

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Type of Examination: Oral examination

Duration of Examination: approx. 30 Minutes

Modality of Exam: The oral exam will be scheduled during the semester break.

The module grade is the grade of the oral exam.

Prerequisites
None.

Recommendation
Basic knowledge of statistics.

T 7.2 Course: Advanced Artificial Intelligence [T-INFO-112768]

Responsible: Prof. Dr. Jan Niehues
Organisation: KIT Department of Informatics
Part of: M-INFO-106299 - Advanced Artificial Intelligence

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each summer term	1

Competence Certificate
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 60 minutes.

Prerequisites
None.

7.3 Course: Advanced Communications Engineering [T-ETIT-113676]

Responsible: Dr.-Ing. Holger Jäkel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106815 - Advanced Communications Engineering

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Competence Certificate
The assessment takes place in the form of a written examination lasting 120 min.

The module grade is the grade of the written exam.

Prerequisites
none

7.4 Course: Analog Circuit Design [T-ETIT-100973]

Responsible: Prof. Dr. Ivan Peric
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100466 - Analog Circuit Design

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2312664	Analog Circuit Design	2 SWS	Lecture / 🧩	Peric
WT 24/25	2312666	Tutorial for 2312664 Analog Circuit Design	1 SWS	Practice / 🧩	Peric

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 7.5 Course: Antennas and Beamforming [T-ETIT-113920]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106956 - Antennas and Beamforming

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	4	Grade to a third	Each winter term	1 terms	1

Competence Certificate
The examination takes place in form of a written examination lasting 120 minutes.
The module grade is the grade of the written exam.

Prerequisites
none

Recommendation
Knowledge of the basics of radio frequency technology and some basic knowledge on communication and radar systems is recommended.

T 7.6 Course: Applied Information Theory [T-ETIT-100748]

Responsible: Dr.-Ing. Holger Jäkel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100444 - Applied Information Theory

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	1

Events					
WT 24/25	2310537	Applied Information Theory	3 SWS	Lecture /	Jäkel
WT 24/25	2310539	Tutorial for 2310537 Applied Information Theory	1 SWS	Practice /	Jäkel

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
The success control takes place in the form of an oral examination lasting 25 minutes. Before the examination, there is a preparation phase of 15 minutes in which preparatory tasks are solved.

Prerequisites
none

T 7.7 Course: Authentication and Encryption [T-INFO-110824]

Responsible: Prof. Dr. Jörn Müller-Quade
Organisation: KIT Department of Informatics
Part of: M-INFO-105338 - Authentication and Encryption

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each summer term	1

T 7.8 Course: Automotive Engineering I [T-MACH-100092]

Responsible: Dr.-Ing. Martin Gießler

Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-100501 - Automotive Engineering I

Type	Credits	Grading scale	Recurrence	Expansion	Language	Version
Written examination	8	Grade to a third	Each winter term	1 terms		3

Events					
WT 24/25	2113805	Automotive Engineering I	4 SWS	Lecture /	Gießler
WT 24/25	2113809	Automotive Engineering I	4 SWS	Lecture /	Gießler

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
Written examination

Duration: 120 minutes

Auxiliary means: none

Prerequisites
The brick "T-MACH-102203 - Automotive Engineering I" is not started or finished. The bricks "T-MACH-100092 - Grundlagen der Fahrzeugtechnik I" and "T-MACH-102203 - Automotive Engineering I" can not be combined.

T 7.9 Course: Automotive Engineering II [T-MACH-102117]

Responsible: Dr.-Ing. Martin Gießler
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-100502 - Automotive Engineering II

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each summer term	1

Events					
ST 2025	2114835	Automotive Engineering II	2 SWS	Lecture / 🗣	Gießler
ST 2025	2114855	Automotive Engineering II	2 SWS	Lecture / 🗣	Gießler

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Written Examination

Duration: 90 minutes

Auxiliary means: none

Prerequisites
none

T 7.10 Course: Automotive Vision [T-MACH-105218]

Responsible: Dr. Martin Lauer
Prof. Dr.-Ing. Christoph Stiller

Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-102693 - Automotive Vision

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each summer term	3

Competence Certificate
Type of Examination: written exam

Duration of Examination: 60 minutes

Prerequisites
none

T 7.11 Course: Basics of Converter Control [T-ETIT-100717]

Responsible: Dr.-Ing. Andreas Liske
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100400 - Basics of Converter Control

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Prerequisites
none

T 7.12 Course: Batteries and Fuel Cells [T-ETIT-113986]

Responsible: Prof. Dr.-Ing. Ulrike Krewer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-107005 - Batteries and Fuel Cells

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Competence Certificate
Success is assessed in the form of a written examination lasting 120 minutes.

The module grade is the grade of the written examination.

Prerequisites
none

T 7.13 Course: Batteries and Fuel Cells [T-ETIT-100983]

Responsible: Prof. Dr.-Ing. Ulrike Krewer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100532 - Batteries and Fuel Cells

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	3

Events					
WT 24/25	2304207	Batteries and Fuel Cells	2 SWS	Lecture / 🧩	Krewer
WT 24/25	2304213	Batteries and Fuel Cells (Exercise to 2304207)	1 SWS	Practice / 🗣	Krewer, Sonder

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.14 Course: Batteries and Fuel Cells Laboratory [T-ETIT-100708]

Responsible: Dr.-Ing. Andre Weber
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100381 - Batteries and Fuel Cells Laboratory

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each winter term	1

Events					
WT 24/25	2304235	Batteries and Fuel Cells Laboratory	4 SWS	Practical course / 🗣	Weber

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 7.15 Course: Battery and Fuel Cells Systems [T-ETIT-100704]

Responsible: Dr.-Ing. Andre Weber
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100377 - Battery and Fuel Cells Systems

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Events					
ST 2025	2304214	Batterie- und Brennstoffzellensysteme	2 SWS	Lecture / 🗣	Weber

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 7.16 Course: Bioelectric Signals [T-ETIT-101956]

Responsible: Dr.-Ing. Axel Loewe
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100549 - Bioelectric Signals

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	2

Events					
ST 2025	2305264	Bioelectric Signals	2 SWS	Lecture / 🗣	Loewe

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The examination is a written examination with a duration of 90 minutes.

Prerequisites
none

7.17 Course: BioMEMS - Microsystems Technologies for Life-Sciences and Medicine I [T-MACH-100966]

Responsible: Prof. Dr. Andreas Guber
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-100489 - BioMEMS - Microsystems Technologies for Life Sciences and Medicine I

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each winter term	2

Events					
WT 24/25	2141864	BioMEMS - Microsystems Technologies for Life-Sciences and Medicine I	2 SWS	Lecture / 🗣	Guber, Ahrens

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
written exam (75 Min.)

Prerequisites
none

T 7.18 Course: BioMEMS - Microsystems Technologies for Life-Sciences and Medicine II [T-MACH-100967]

Responsible: Prof. Dr. Andreas Guber
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-100490 - BioMEMS - Microsystems Technologies for Life Sciences and Medicine II

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each summer term	2

Competence Certificate
Written exam (75 Min.)

Prerequisites
none

T 7.19 Course: BioMEMS - Microsystems Technologies for Life-Sciences and Medicine III [T-MACH-100968]

Responsible: Prof. Dr. Andreas Guber
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-100491 - BioMEMS - Microsystems Technologies for Life Sciences and Medicine III

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each summer term	2

Competence Certificate
Written exam (75 Min.)

Prerequisites
none

T 7.20 Course: Business Innovation in Optics and Photonics [T-ETIT-104572]

Responsible: Prof. Dr. Werner Nahm
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-101834 - Business Innovation in Optics and Photonics

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2305742	Business Innovation in Optics and Photonics	2 SWS	Lecture / 🗣	Riedel, Nahm
WT 24/25	2305743	Erxercise for 2305742 Business Innovation in Optics and Photonics	1 SWS	Practice / 🗣	Riedel, Nahm

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Competence Certificate
Type of Examination: examination of another type

Duration of Examination: 4 group presentations à 20 minutes (approx.)

Modality of Exam: The exam consists of four group presentations. 2nd day: Technology Presentation. 3rd day: Development plan presentation. 4th day: Business Canvas presentation. Final presentation at Zeiss visit: Business pitch

Prerequisites
Good knowledge in optics & photonics.

T 7.21 Course: Channel Coding: Algebraic Methods for Communications and Storage [T-ETIT-111244]

Responsible: Prof. Dr.-Ing. Laurent Schmalen
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105616 - Channel Coding: Algebraic Methods for Communications and Storage

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Each summer term	1 terms	1

Competence Certificate
The exam is held as an oral exam of 20 Min according to 4 Abs. 2 Nr. 1 SPO Bachelor/Master Elektrotechnik und Informationstechnik. Grade of the module corresponds to the grade of the oral exam.

Prerequisites
none

Recommendation
Previous attendance of the lectures "Communication Engineering I" and "Probability Theory" is recommended.

T 7.22 Course: Channel Coding: Graph-Based Codes [T-ETIT-111245]

Responsible: Prof. Dr.-Ing. Laurent Schmalen
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105617 - Channel Coding: Graph-Based Codes

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	6	Grade to a third	Each winter term	1 terms	1

Events					
WT 24/25	2310520	Channel Coding: Graph-Based Codes	3 SWS	Lecture /	Schmalen
WT 24/25	2310521	Exercise for 2310520 Channel Coding: Graph-Based Codes	1 SWS	Practice /	Schmalen

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
The success control takes place in the form of an oral examination lasting 25 minutes. Before the examination, there is a preparation phase of 30 minutes in which preparatory tasks are solved.

Prerequisites
none

Recommendation
Previous attendance of the lectures "Communication Engineering I" and "Theory of Probability" is recommended. Knowledge from the lectures "Applied Information Theory" and "Verfahren der Kanalcodierung" is helpful.

T 7.23 Course: Communication Systems and Protocols [T-ETIT-101938]

Responsible: Dr.-Ing. Jens Becker
Prof. Dr.-Ing. Jürgen Becker
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100539 - Communication Systems and Protocols

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each summer term	1

Prerequisites
none

T 7.24 Course: Communications Engineering II [T-ETIT-110697]

Responsible: Dr.-Ing. Holger Jäkel
Prof. Dr.-Ing. Laurent Schmalen

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: M-ETIT-105274 - Communications Engineering II

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	4	Grade to a third	Each term	1 terms	1

Events					
WT 24/25	2310509	Communications Engineering II	2 SWS	Lecture / 🗘	Jäkel
WT 24/25	2310510	Übung zu 2310509 Communications Engineering II	1 SWS	Practice / 🗘	Jäkel

Legend: 🖥 Online, 🗘 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment will be carried out in the form of a written exam of 120 minutes. The module grade is the grade of the written exam.

Prerequisites
none

Recommendation
Knowledge of basic engineering mathematics including integral transformations and probability theory as well as basic knowledge of communications engineering.

Previous visit to the lecture "Communications Engineering I", "Probability Theory" and "Signals and Systems" is recommended.

T 7.25 Course: Communications Engineering Laboratory [T-ETIT-100746]

Responsible: Dr.-Ing. Holger Jäkel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100442 - Communications Engineering Laboratory

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each term	1

Events					
WT 24/25	2310517	Communication Engineering Laboratory	4 SWS	Practical course /	Schmalen, Jäkel, Edelmann

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Prerequisites
none

T 7.26 Course: Components of Power Systems [T-ETIT-113445]

Responsible: Prof. Dr.-Ing. Thomas Leibfried
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106689 - Components of Power Systems

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Competence Certificate
The examination takes place in form of an oral examination lasting approx. 20 minutes.
The module grade is the grade of the oral exam.

Prerequisites
none

7.27 Course: Computational Imaging [T-INFO-112573]

Responsible: Dr.-Ing. Johannes Meyer
Organisation: KIT Department of Informatics
Part of: M-INFO-106190 - Computational Imaging

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	1

Events					
WT 24/25	2400173	Computational Imaging	3 SWS	Lecture / Practice (/	Meyer, Beyerer

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 60 minutes.

Prerequisites
None.

T 7.28 Course: Computational Intelligence [T-MACH-105314]

Responsible: Stefan Meisenbacher
apl. Prof. Dr. Ralf Mikut
apl. Prof. Dr. Markus Reischl

Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-105296 - Computational Intelligence

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2105016	Computational Intelligence	2 SWS	Lecture /	Mikut, Reischl, Meisenbacher

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
Written exam (Duration: 1h)

Prerequisites
none

T 7.29 Course: Control of Linear Multivariable Systems [T-ETIT-100666]

Responsible: Dr.-Ing. Mathias Kluwe
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100374 - Control of Linear Multivariable Systems

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 24/25	2303177	Control of Linear Multivariable Systems	3 SWS	Lecture / 🗣	Kluwe
WT 24/25	2303179	Control of Linear Multivariable Systems (Tutorial to 2303177)	1 SWS	Practice / 🗣	Fehn

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Success is checked as part of a written overall test (120 minutes) of the course.

Prerequisites
none

Recommendation
For a deeper understanding, basic knowledge of system dynamics and control technology is absolutely necessary, as taught in the ETIT Bachelor module "System Dynamics and Control Technology" M-ETIT-102181.

T 7.30 Course: Control of Power-Electronic Systems [T-ETIT-111897]

Responsible: Dr.-Ing. Andreas Liske
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105915 - Control of Power-Electronic Systems

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

T 7.31 Course: Control Technology [T-MACH-105185]

Responsible: Hon.-Prof. Dr. Christoph Gönnheimer
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-105348 - Control Technology

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each summer term	2

Events					
ST 2025	2150683	Control Technology	2 SWS	Lecture / 🗣	Gönnheimer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Written Exam (60 min)

Prerequisites
none

T 7.32 Course: Control Theory Laboratory [T-ETIT-111009]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105467 - Control Theory Laboratory

Type	Credits	Grading scale	Recurrence	Expansion	Version
Examination of another type	6	Grade to a third	Each term	1 terms	1

Events					
WT 24/25	2303169	Control Theory Laboratory	4 SWS	Block / 🗣	Hohmann

Legend: 🖥 Online, ⚃ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.33 Course: Cryogenic Engineering [T-CIWVT-108915]

Responsible: Prof. Dr.-Ing. Steffen Grohmann
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-104356 - Cryogenic Engineering

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	1

Events					
WT 24/25	2250140	Cryogenic Engineering	2 SWS	Lecture / 🗣	Grohmann
WT 24/25	2250141	Cryogenic Engineering - Exercises	1 SWS	Practice / 🗣	Grohmann

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The examination is an oral examination with a duration of about 30 minutes (section 4 subsection 2 number 2 SPO).

Prerequisites
None

T 7.34 Course: Cryptographic Protocols [T-INFO-111261]

Responsible: Dr. Willi Geiselmann
Prof. Dr. Jörn Müller-Quade

Organisation: KIT Department of Informatics

Part of: M-INFO-105631 - Cryptographic Protocols

Type	Credits	Grading scale	Recurrence	Version
Oral examination	5	Grade to a third	Each summer term	2

T 7.35 Course: Current Topics of Solar Energy [T-ETIT-100780]

Responsible: Prof. Dr.-Ing. Michael Powalla
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100507 - Current Topics of Solar Energy

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2313748	Aktuelle Themen der Solarenergie	2 SWS	Seminar /	Powalla

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Prerequisites
none

T 7.36 Course: Cyber Physical Production Systems [T-ETIT-112223]

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: M-ETIT-106039 - Cyber Physical Production Systems

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each summer term	1

Competence Certificate

The examination takes place within the framework of an oral overall examination (20 minutes).

The module grade is the grade of the oral exam.

Prerequisites

none

T 7.37 Course: Cyber-Physical Modeling [T-ETIT-113908]

Responsible: Prof. Dr.-Ing. Mike Barth
Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106953 - Cyber-Physical Modeling

Type	Credits	Grading scale	Version
Written examination	6	Grade to a third	1

Events					
ST 2025	2303310	Cyber Physical Modeling	3 SWS	Lecture / 🗣	Hohmann, Barth
ST 2025	2303311	Tutorial to 2303310 Cyber Physical Modeling	1 SWS	Practice / 🗣	Hohmann, Barth

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The examination takes place in the form of a written examination lasting 90 min.
The module grade is the grade of the written exam.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-ETIT-111013 - Physical and Data-Based Modelling must not have been started.
2. The course T-ETIT-112223 - Cyber Physical Production Systems must not have been started.

T 7.38 Course: Data Science [T-INFO-113124]

Responsible: Prof. Dr.-Ing. Klemens Böhm
Organisation: KIT Department of Informatics
Part of: M-INFO-106505 - Data Science

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each winter term	2

Events					
WT 24/25	24114	Data Science 1	3 SWS	Lecture / 🗣	Böhm, Kalinke

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
None.

T 7.39 Course: Deep Learning and Neural Networks [T-INFO-109124]

Responsible: Prof. Dr. Jan Niehues
Organisation: KIT Department of Informatics
Part of: M-INFO-104460 - Deep Learning and Neural Networks

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each summer term	1

Competence Certificate
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 60 minutes.

Prerequisites
T-INFO-101383 - Neural networks must not be started.

Recommendation
Prior successful completion of the core module "Cognitive Systems" is recommended.

T 7.40 Course: Deep Learning for Computer Vision I: Basics [T-INFO-111491]

Responsible: Prof. Dr.-Ing. Rainer Stiefelhagen
Organisation: KIT Department of Informatics
Part of: M-INFO-105753 - Deep Learning for Computer Vision I: Basics

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	2

Events					
ST 2025	2400007	Deep Learning for Computer Vision I: Basics	2 SWS	Lecture / 🗣	Stiefelhagen, Reiß

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 120 minutes.

Prerequisites
None.

Recommendation
Basic knowledge of pattern recognition as taught in the module Cognitive Systems, is expected.

Annotation
The course is partially given in German and English.

T 7.41 Course: Deep Learning for Computer Vision II: Advanced Topics [T-INFO-111494]

Responsible: Prof. Dr.-Ing. Rainer Stiefelhagen
Organisation: KIT Department of Informatics
Part of: M-INFO-105755 - Deep Learning for Computer Vision II: Advanced Topics

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each winter term	2

Events					
WT 24/25	2400258	Deep Learning for Computer Vision II: Advanced Topics	2 SWS	Lecture / 🗣	Stiefelhagen, Sarfraz, Reiß

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 7.42 Course: Design and Architectures of Embedded Systems (ES2) [T-INFO-101368]

Responsible: Prof. Dr.-Ing. Jörg Henkel
Organisation: KIT Department of Informatics
Part of: M-INFO-100831 - Design and Architectures of Embedded Systems (ES2)

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2424106	Design and architectures of embedded systems (ES2)	2 SWS	Lecture	Khdr, Henkel

Competence Certificate
The assessment is carried out as an oral examination (§ 4 Abs. 2 Nr. 2 SPO) lasting 20 minutes.

Prerequisites
None.

Recommendation
Knowledge of computer structures is helpful.

T 7.43 Course: Design of Electrical Machines [T-ETIT-100785]

Responsible: Prof. Dr. Martin Doppelbauer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100515 - Design of Electrical Machines

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	2

Events					
WT 24/25	2306324	Design of Electrical Machines	2 SWS	Lecture / 🧩	Doppelbauer
WT 24/25	2306325	Tutorial for 2306324 Design of Electrical Machines	1 SWS	Practice / 🧩	Doppelbauer

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

Recommendation
Modul: Elektrische Maschinen und Stromrichter

T 7.44 Course: Detectors for Applications in Space and Astronomy [T-ETIT-100761]

Responsible: Prof. Theo Scherer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100541 - Detectores for Applications in Space and Astronomy

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2312678	Detectores for Applications in Space and Astronomy	2 SWS	Lecture	Scherer

Prerequisites
none

T 7.45 Course: Digital Beam-Forming for Imaging Radar [T-ETIT-110940]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105415 - Digital Beam-Forming for Imaging Radar

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2308450	Digital Beam-Forming for Imaging Radar	2 SWS	Lecture / 🗣	Younis
WT 24/25	2308451	Tutorial for 2308450 Digital Beam-Forming for Imaging Radar	1 SWS	Practice / 🗣	Younis

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Written Exam approx. 120 Min.

Prerequisites
The basic principles will be repeated in the lecture. The following lectures are helpful for a comprehensive understanding: Radar System Engineering (engl.), Antennen und Mehrantennensysteme, Spaceborne Radar Remote Sensing (engl.), Modern Radio System Engineering (engl.)

Recommendation
Basics of signal processing and radar techniques are useful.

T 7.46 Course: Digital Circuit Design [T-ETIT-100974]

Responsible: Prof. Dr. Ivan Peric
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100473 - Digital Circuit Design

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each summer term	1

T 7.47 Course: Digital Hardware Design Laboratory [T-ETIT-104570]

Responsible: Prof. Dr.-Ing. Jürgen Becker
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-102264 - Digital Hardware Design Laboratory

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each summer term	1

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-ETIT-102266 - Digital Hardware Design Laboratory must not have been started.

T 7.48 Course: Digital Hardware Design Laboratory [T-ETIT-104571]

Responsible: Prof. Dr.-Ing. Jürgen Becker
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-102266 - Digital Hardware Design Laboratory

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each summer term	1

Competence Certificate
Control of success is carried out in an oral examination as well as during the laboratory exercises in form of laboratory reports and/or oral interrogations.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-ETIT-102264 - Digital Hardware Design Laboratory must not have been started.

Recommendation
Previous knowledge in design and design automation for electronic systems (e.g. from the lectures SAE, No. 23606, HSO, No. 23619 or HMS, No. 23608) is recommended.

Annotation
The module ETIT-102264 („Praktikum Entwurf digitaler Systeme“) must not have been started or completed.

T 7.49 Course: Digital Real Time Simulations for Energy Technologies [T-ETIT-113449]

Responsible: Prof. Dr.-Ing. Giovanni De Carne
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106690 - Digital Real Time Simulations for Energy Technologies

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	1

Competence Certificate
The examination takes place in form of other types of examination. It consists of an assessment from an exercise on HiL and an oral overall examination (approx. 15 minutes) explaining the exercise results. The overall impression is evaluated.
The module grade results of the assessment of an exercise and the oral exam. Details will be given during the lecture.

Prerequisites
none

T 7.50 Course: Digital Signal Processing in Optical Communications – with Practical Exercises [T-ETIT-106852]

Responsible: Prof. Dr.-Ing. Sebastian Randel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-103450 - Digital Signal Processing in Optical Communications – with Practical Exercises

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each summer term	2

Competence Certificate
The exercise sheets and the oral questionnaire are used to rate other types of examinations. The overall impression is assessed. Duration about 20 minutes.

Prerequisites
Basic knowledge of optical communication systems. Proven, for example, by completing one of the modules "Optical Networks and Systems-ONS", "Optoelectronic Components -OC, or" Optical Transmitters and Receivers - OTR.

Recommendation
Knowledge of the basics of optical communication technology and digital signal processing is helpful.

7.51 Course: Digital Twin Engineering [T-ETIT-112224]

Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106040 - Digital Twin Engineering

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2301486	Digital Twin Engineering	2 SWS	Lecture / 🗣	Barth, Witucki

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The examination takes place in form of other types of examination. It consists of a model library developed in the course of a semester-long project in the modeling language Modelica and a presentation of the library lasting 25 minutes. The quality of the model library is evaluated within the framework of the criteria: documentation, formal correctness, functionality, usability, HMI and modeling level of detail. The presentation is evaluated as an additional aspects. The overall impression is evaluated.

The assessment of the developed model library and the presentation of the library will be included in the module grade. More details will be given at the beginning of the course.

Prerequisites
none

T 7.52 Course: Distributed Discrete Event Systems [T-ETIT-100960]

Responsible: Prof. Dr.-Ing. Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100361 - Distributed Discrete Event Systems

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each summer term	1

Events					
ST 2025	2302106	Verteilte ereignisdiskrete Systeme	2 SWS	Lecture / Blended	Heizmann
ST 2025	2302108	Übungen zu 2302106 Verteilte ereignisdiskrete Systeme	1 SWS	Practice / On-Site	Hoffmann

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Prerequisites
none

T 7.53 Course: Dosimetry of Ionising Radiation [T-ETIT-104505]

Responsible: PD Dr. Bastian Breustedt
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-101847 - Dosimetry of Ionising Radiation

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each winter term	2

Events					
WT 24/25	2305294	Dosimetry of Ionising Radiation	2 SWS	Lecture / 🗣	Breustedt

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Success control is carried out as part of an overall written examination (2 h).

Prerequisites
none

T 7.54 Course: Electric Drives for E-Mobility [T-ETIT-113936]

Responsible: Prof. Dr. Martin Doppelbauer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106971 - Electric Drives for E-Mobility

Type	Credits	Grading scale	Version
Written examination	4	Grade to a third	1

Competence Certificate
The success control takes place in the form of an oral examination of approximately 30 minutes.

Prerequisites
none

Recommendation
Basic knowledge in the field of electric machines and drives is helpful, for example by attending the course "Elektrische Maschinen und Stromrichter (EMS)" in the KIT-Bachelor.

Basic knowledge in the field of hybrid and electric vehicles is helpful, for example by attending the course "Hybridelektrische Fahrzeuge HEF)" in the KIT-Bachelor.

T 7.55 Course: Electric Power Generation and Power Grid [T-ETIT-103608]

Responsible: Dr.-Ing. Bernd Hoferer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-101917 - Electric Power Generation and Power Grid

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2307399	Electric Power Generation and Power Grid	2 SWS	Lecture / 🗣	Hoferer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.56 Course: Electric Power Transmission & Grid Control [T-ETIT-110883]

Responsible: Prof. Dr.-Ing. Thomas Leibfried
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105394 - Electric Power Transmission & Grid Control

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	6	Grade to a third	Each summer term	1 terms	2

Events					
WT 24/25	2307376	Electric Power Transmission & Grid Control	2 SWS	Lecture / ✕	Leibfried

Legend: Online, Blended (On-Site/Online), On-Site, ✕ Cancelled

Competence Certificate
The examination takes place in form of a written examination lasting 120 minutes. The module grade is the grade of the written exam.

Prerequisites
none

T 7.57 Course: Electrocatalysis [T-ETIT-111831]

Responsible: Dr. Philipp Röse
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105883 - Electrocatalysis

Type	Credits	Grading scale	Version
Written examination	5	Grade to a third	2

Events					
ST 2025	2304300	Electrocatalysis	3 SWS	Lecture / 🗣	Röse
ST 2025	2304301	Exercise to 2304300 Electrocatalysis	1 SWS	Practice / 🗣	Röse

Legend: 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The examination takes place in form of a written examination lasting 120 minutes.

T 7.58 Course: Electromagnetics and Numerical Calculation of Fields [T-ETIT-100640]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100386 - Electromagnetics and Numerical Calculation of Fields

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2308263	Electromagnetics and Numerical Calculation of Fields	2 SWS	Lecture / 🗣	Pauli
WT 24/25	2308265	Exercise for 2308263 Electromagnetics and Numerical Calculation of Fields	1 SWS	Practice / 🗣	Pauli, Giroto de Oliveira

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Success control is carried out in the form of a written test of 120 minutes.

Prerequisites
none

Recommendation
Fundamentals of electromagnetic field theory.

T 7.59 Course: Electronic Circuits for Light Sources and Laser [T-ETIT-100783]

Responsible: Dr.-Ing. Rainer Kling
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100511 - Electronic Circuits for Light Sources and Laser

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Prerequisites
none

T 7.60 Course: Electronics and EMC [T-ETIT-100723]

Responsible: Dr. Martin Sack
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100410 - Electronics and EMC

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

T 7.61 Course: Energy from Biomass [T-CIWVT-108828]

Responsible: Dr.-Ing. Siegfried Bajohr
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-104288 - Biomass Based Energy Carriers

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	1

Events					
WT 24/25	2231510	Biomass Based Energy Carriers	2 SWS	Lecture / 🗣	Bajohr
WT 24/25	2231511	Exercises on 2231510 Biomass Based Energy Carriers	1 SWS	Practice / 🗣	Bajohr, und Mitarbeitende

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The examination is an oral examination with a duration of about 20 minutes (section 4 subsection 2 number 2 SPO).

Prerequisites
None

T 7.62 Course: Energy Storage and Network Integration [T-ETIT-104644]

Responsible: Prof. Dr.-Ing. Mathias Noe
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-101969 - Energy Storage and Network Integration

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2312687	Energy Storage and Network Integration	2 SWS	Lecture / 🗣	Grilli, De Carne
WT 24/25	2312689	Tutorial for 2312687 Energy Storage and Network Integration	1 SWS	Practice / 🗣	De Carne, Grilli

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
Neither participation in "Energiespeicher und Netzintegration" (ETIT) nor in "Energiespeicher und Netzintegration" (MACH). Only one out of these three exams is allowed.

Recommendation
Basic knowledge in the fields of Electrical Engineering and Thermodynamics is helpful.

Annotation
Exam and Lecture will be held in English.

T 7.63 Course: Entrepreneurship [T-WIWI-102864]

Responsible: Prof. Dr. Orestis Terzidis
Organisation: KIT Department of Economics and Management
Part of: M-ETIT-105073 - Student Innovation Lab

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each term	1

Events					
WT 24/25	2545001	Entrepreneurship	2 SWS	Lecture / 🧩	Terzidis, Dang
ST 2025	2545001	Entrepreneurship	2 SWS	Lecture / 🧩	Terzidis, Dang

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment consists of a written exam (60 minutes) (following §4(2), 1 of the examination regulation).

Students are offered the opportunity to earn a grade bonus through separate assignments. If the grade of the written exam is between 4.0 and 1.3, the bonus improves the grade by a maximum of one grade level (0.3 or 0.4). The exact criteria for awarding a bonus will be announced at the beginning of the lecture.

Prerequisites
None

Recommendation
None

T 7.64 Course: Fabrication and Characterisation of Optoelectronic Devices [T-ETIT-103613]

Responsible: Prof. Dr. Bryce Sydney Richards
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-101919 - Fabrication and Characterisation of Optoelectronic Devices

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	1

Prerequisites
none

T 7.65 Course: Field Propagation and Coherence [T-ETIT-100976]

Responsible: Prof. Dr. Wolfgang Freude
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100566 - Field Propagation and Coherence

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2309466	Field Propagation and Coherence	2 SWS	Lecture / 🗣	Freude
WT 24/25	2309467	Tutorial for 2309466 Field Propagation and Coherence	1 SWS	Practice / 🗣	Freude, N.N.

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.66 Course: Fundamentals of Automobile Development I [T-MACH-105162]

Responsible: Dr. Manfred Harrer
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-105289 - Principles of Whole Vehicle Engineering I

Type	Credits	Grading scale	Recurrence	Version
Written examination	2	Grade to a third	Each winter term	1

Events					
WT 24/25	2113810	Fundamentals of Automobile Development I	1 SWS	Lecture / 🗣	Harrer
WT 24/25	2113851	Principles of Whole Vehicle Engineering I	1 SWS	Lecture / 🗣	Harrer

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Written examination

Duration: 90 minutes

Auxiliary means: none

Prerequisites
none

T 7.67 Course: Fundamentals of Automobile Development II [T-MACH-105163]

Responsible: Dr. Manfred Harrer
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-105290 - Principles of Whole Vehicle Engineering II

Type	Credits	Grading scale	Recurrence	Version
Written examination	2	Grade to a third	Each summer term	2

Events					
ST 2025	2114842	Principles of Whole Vehicle Engineering II	1 SWS	Block / 🗣	Harrer
ST 2025	2114860	Principles of Whole Vehicle Engineering II	1 SWS	/ 🗣	Harrer

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Written examination

Duration: 90 minutes

Auxiliary means: none

Prerequisites
none

T 7.68 Course: Fundamentals on Plasma Technology [T-ETIT-100770]

Responsible: Dr.-Ing. Rainer Kling
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100483 - Fundamentals on Plasma Technology

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Prerequisites
none

T 7.69 Course: Geodetic Space Techniques for Engineers, Exam [T-BGU-112871]

Responsible: Prof. Dr.-Ing. Hansjörg Kutterer
Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences
Part of: M-BGU-106347 - Geodetic Space Techniques for Engineers

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Each winter term	1 terms	1

Events					
WT 24/25	6020161	Geodetic Spatial Methods	2 SWS	Lecture / 🗣	Kutterer
WT 24/25	6020162	Geodetic Spatial Methods, Exercises	1 SWS	Practice / 🗣	Seitz, Mayer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-BGU-111169 - Geodetic Space Techniques, Prerequisite must have been passed.

T 7.70 Course: Geodetic Space Techniques, Prerequisite [T-BGU-111169]

Responsible: Prof. Dr.-Ing. Hansjörg Kutterer
Dr. Kurt Seitz

Organisation: KIT Department of Civil Engineering, Geo and Environmental Sciences

Part of: M-BGU-106347 - Geodetic Space Techniques for Engineers

Type	Credits	Grading scale	Recurrence	Expansion	Version
Completed coursework	1	pass/fail	Each winter term	1 terms	1

Prerequisites
none

T 7.71 Course: Handling Characteristics of Motor Vehicles I [T-MACH-105152]

Responsible: Dr.-Ing. Hans-Joachim Unrau
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-105288 - Handling Characteristics of Motor Vehicles I

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2113807	Handling Characteristics of Motor Vehicles I	2 SWS	Lecture / 🖥	Unrau

Legend: 🖥 Online, Blended (On-Site/Online), On-Site, × Cancelled

Competence Certificate
Verbally

Duration: 30 up to 40 minutes

Auxiliary means: none

Prerequisites
none

T 7.72 Course: Hardware Modeling and Simulation [T-ETIT-100672]

Responsible: Dr.-Ing. Jens Becker
Prof. Dr.-Ing. Jürgen Becker

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: M-ETIT-100449 - Hardware Modeling and Simulation

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each winter term	2

Events					
WT 24/25	2311608	Hardware Modeling and Simulation	2 SWS	Lecture / 🗣	Becker, Becker
WT 24/25	2311610	Tutorial for 2311608 Hardware Modeling and Simulation	1 SWS	Practice / 🗣	Unger

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Achievement is examined in the form of a written examination lasting 120 minutes.

Prerequisites
none

T 7.73 Course: Hardware Synthesis and Optimization [T-ETIT-113922]

Responsible: Prof. Dr.-Ing. Jürgen Becker
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106963 - Hardware Synthesis and Optimization

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

Competence Certificate
The examination takes place within the framework of an oral overall examination (approx. 30 minutes).
The module grade is the grade of the written exam.

Prerequisites
none

T 7.74 Course: Hardware/Software Co-Design [T-ETIT-100671]

Responsible: Dr.-Ing. Tanja Harbaum
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100453 - Hardware/Software Co-Design

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2311620	Hardware/Software Co-Design	2 SWS	Lecture / 🗣	Harbaum, Becker
WT 24/25	2311623	Tutorial for 2311620 Hardware/ Software Co-Design	1 SWS	Practice / 🗣	Gutermann

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, x Cancelled

Competence Certificate
Achievement will be examined in an oral examination (approx. 20 minutes).

Prerequisites
none

7.75 Course: High-Power Microwave Technology [T-ETIT-100791]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100521 - High-Power Microwave Technology

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2308435	High-Power Microwave Technology	2 SWS	Lecture / 🗣	Jelonnek, Marek

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.76 Course: High-Voltage Technology [T-ETIT-110266]

Responsible: Dr.-Ing. Rainer Badent
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105060 - High-Voltage Technology

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	6	Grade to a third	Each winter term	1 terms	1

Events					
WT 24/25	2307360	High-Voltage Technology	2 SWS	Lecture / 🗣	Badent
WT 24/25	2307362	Tutorial for 2307362High-Voltage Technology	1 SWS	Practice / 🗣	Badent, Zajadatz

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 7.77 Course: High-Voltage Test Technique [T-ETIT-101915]

Responsible: Dr.-Ing. Rainer Badent
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100417 - High-Voltage Test Technique

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2307392	High-Voltage Test Technique	2 SWS	Lecture / 🗣	Badent
WT 24/25	2307394	Tutorial for 2307392 High-Voltage Test Technique	2 SWS	Practice / 🗣	Gielnik

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.78 Course: Human Brain and Central Nervous System: Anatomy, Information Transfer, Signal Processing, Neurophysiology and Therapy [T-INFO-101262]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Hon.-Prof. Dr. Uwe Spetzger

Organisation: KIT Department of Informatics

Part of: M-INFO-100725 - Human Brain and Central Nervous System: Anatomy, Information Transfer, Signal Processing, Neurophysiology and Therapy

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each term	2

Events					
WT 24/25	2424139	Human Brain and Central Nervous System: Anatomy, Information Transfer, Signal Processing, Neurophysiology and Therapy	2 SWS	Lecture / 🗣	Spetzger

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 7.79 Course: Image Processing [T-ETIT-105566]

Responsible: Prof. Dr.-Ing. Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-102651 - Image Processing

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	1

Events					
ST 2025	2302114	Bildverarbeitung	2 SWS	Lecture /	Heizmann

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Prerequisites
none

T 7.80 Course: Industrial Circuitry [T-ETIT-100716]

Responsible: Dr.-Ing. Andreas Liske
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100399 - Industrial Circuitry

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2306327	Industrial Circuitry	2 SWS	Lecture / 🔀	Liske

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Prerequisites
none

7.81 Course: Information Fusion [T-ETIT-106499]

Responsible: Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-103264 - Information Fusion

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2302139	Information Fusion	2 SWS	Lecture /	Heizmann
WT 24/25	2302141	Erxercize for 2302139 Information Fusion	1 SWS	Practice /	Heizmann, Bihler

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Prerequisites
none

T 7.82 Course: Information Technology in Industrial Automation Systems [T-ETIT-100698]

Responsible: Dr.-Ing. Peter-Axel Bort
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100367 - Information Technology in Industrial Automation Systems

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Events					
ST 2025	2302144	Informationstechnik in der industriellen Automation	2 SWS	Lecture / 🗣	Bort

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

7.83 Course: Innovation Lab [T-ETIT-110291]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Prof. Dr. Werner Nahm
Prof. Dr.-Ing. Eric Sax
Prof. Dr. Wilhelm Stork
Prof. Dr.-Ing. Thomas Zwick

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: M-ETIT-105073 - Student Innovation Lab

Type	Credits	Grading scale	Recurrence	Expansion	Version
Examination of another type	9	Grade to a third	Each winter term	2 terms	1

Events					
WT 24/25	2303192	Innovation Lab	2 SWS	Project (P / 🗣	Hohmann, Zwick, Sax, Stork, Nahm, Schmalen, Rost

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
see module description

T 7.84 Course: Integrated Intelligent Sensors [T-ETIT-100961]

Responsible: Prof. Dr. Wilhelm Stork
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100457 - Integrated Intelligent Sensors

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Competence Certificate
Achievement will be examined in an oral examination (approx. 20 minutes).

Prerequisites
none

T 7.85 Course: Integrated Systems and Circuits [T-ETIT-100972]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100474 - Integrated Systems and Circuits

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each summer term	2

Prerequisites
none

T 7.86 Course: Interfaculty Team Project [T-ETIT-106110]

Responsible: Dr.-Ing. Rainer Kling
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-103076 - Interfaculty Team Project

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each summer term	1

Prerequisites
none

T 7.87 Course: Introduction to Automotive and Industrial Lidar Technology [T-ETIT-111011]

Responsible: Prof. Dr. Wilhelm Stork
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105461 - Introduction to Automotive and Industrial Lidar Technology

Type	Credits	Grading scale	Recurrence	Expansion	Version
Examination of another type	3	Grade to a third	Each winter term	1 terms	2

Events					
WT 24/25	2311604	Introduction to automotive and industrial Lidar technology	2 SWS	Lecture /	Stork, Heußner

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

T 7.88 Course: Introduction to Energy Economics [T-WIWI-102746]

Responsible: Prof. Dr. Wolf Fichtner
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-100498 - Introduction into Energy Economics

Type	Credits	Grading scale	Recurrence	Version
Written examination	5,5	Grade to a third	Each summer term	6

Events					
ST 2025	2581010	Introduction to Energy Economics	2 SWS	Lecture / 🗣	Fichtner
ST 2025	2581011	Übungen zu Einführung in die Energiewirtschaft	2 SWS	Practice / 🗣	Sandmeier, Fichtner, Scharnhorst

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Competence Certificate
The assessment consists of a written exam (90 minutes) (following §4(2) of the examination regulation). The exam takes place in every semester. Re-examinations are offered at every ordinary examination date. Depending on the respective pandemic situation, the exam may be offered as an open book exam (alternative exam assessment, following §4(2), 3 of the examination regulation).

Prerequisites
None.

T 7.89 Course: Introduction to Microsystem Technology I [T-MACH-105182]

Responsible: Dr. Vlad Badilita
Dr. Mazin Jouda
Prof. Dr. Jan Gerrit Korvink

Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-102691 - Introduction to Microsystem Technology I

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2141861	Introduction to Microsystem Technology I	2 SWS	Lecture / 🗣	Korvink, Badilita

Legend: 🖥 Online, ❖ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Competence Certificate
written examination (60 min)

Prerequisites
none

T 7.90 Course: Introduction to Video Analysis [T-INFO-101273]

Responsible: Prof. Dr.-Ing. Jürgen Beyerer
Organisation: KIT Department of Informatics
Part of: M-INFO-100736 - Introduction to Video Analysis

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Events					
ST 2025	24684	Introduction to Video Analysis	2 SWS	Lecture / 🗣	Arens

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 7.91 Course: IT/OT-Security Seminar [T-ETIT-113648]

Responsible: Prof. Dr.-Ing. Mike Barth
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106789 - IT/OT-Security Seminar

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	4	Grade to a third	Each winter term	1 terms	1

Events					
WT 24/25	2303201	IT/OT-Security Seminar	2 SWS	Seminar /	Barth, Madsen

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
The examination takes place in the form of an oral examination.

The module grade is the grade of the oral exam.

Prerequisites
none

T 7.92 Course: Lab Course Electrical Drives and Power Electronics [T-ETIT-100718]

Responsible: Prof. Dr. Martin Doppelbauer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100401 - Lab Course Electrical Drives and Power Electronics

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

Events					
ST 2025	2306331	Lab Course Electrical Drives and Power Electronics	4 SWS	Practical course / 🗣	Brodatzki, Hiller

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.93 Course: Lab Course Electrical Power Engineering [T-ETIT-100728]

Responsible: Dr.-Ing. Rainer Badent
Prof. Dr. Martin Doppelbauer
Prof. Dr.-Ing. Thomas Leibfried

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: M-ETIT-100419 - Lab Course Electrical Power Engineering

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each winter term	2

Events					
WT 24/25	2307398	Lab Course Electrical Power Engineering	4 SWS	Practical course / 🗣	Badent, Brodatzki, N.N.

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.94 Course: Lab Course on Nanoelectronics [T-ETIT-100757]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100468 - Lab Course on Nanoelectronics

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each term	1

Events					
WT 24/25	2312669	Laboratory Nanoelectronics	4 SWS	Practical course / 🗣	Kempf, weitere Mitarbeitende
ST 2025	2312669	Laboratory Nanoelectronic Technology	4 SWS	Practical course / 🗣	Kempf, Mitarbeiter*innen

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.95 Course: Lab Course on Noise Thermometry [T-ETIT-112714]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106263 - Lab Course on Noise Thermometry

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each term	1

Events					
WT 24/25	2312682	Lab Course on Noise Thermometry	4 SWS	Practical course / 🗣	Kempf, weitere Mitarbeitende
ST 2025	2312682	Lab Course on Noise Thermometry	4 SWS	Practical course / 🗣	Kempf, Mitarbeiter*innen

Legend: 🖥 Online, ✲ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The examination takes place in form of other types of examination. It is based on the evaluation of a written report (approx. 10-20 pages) which introduces the topic, discusses the execution of the lab course and the scientific results and finally puts the results into the overall context.

Prerequisites
none

T 7.96 Course: Lab Course on Superconducting Quantum Electronics [T-ETIT-111233]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105605 - Lab Course on Superconducting Quantum Electronics

Type	Credits	Grading scale	Recurrence	Expansion	Version
Examination of another type	6	Grade to a third	Each term	1 terms	1

Events					
WT 24/25	2312715	Praktikum Supraleitende Quantenelektronik	4 SWS	Practical course / 🗣	Kempf, weitere Mitarbeitende
ST 2025	2312675	Praktikum Supraleitende Quantenelektronik	4 SWS	Practical course / 🗣	Kempf, Mitarbeiter*innen

Legend: 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Prerequisites
none

T 7.97 Course: Lab Course Printed Flexible Electronics [T-ETIT-113075]

Responsible: Prof. Dr. Gerardo Hernandez Sosa
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106464 - Lab Course Printed Flexible Electronics

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	6	pass/fail	Each term	2

Events					
WT 24/25	2313765	Lab Course Printed Flexible Electronics	4 SWS	Practical course / 🗣	Hernandez Sosa

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The examination consists of a written journal article and an oral presentation of the student's work, both given in English. The overall impression is rated.

The module is passed with successful assessment of the written paper and the oral presentation. Details will be given during the lecture. The module is ungraded.

Prerequisites
The M-ETIT-100475 Modul: Plastic Electronics / Polymerelektronik should be started.

Annotation
- The lab is limited to a number of 6 participants due to capacity reasons. If necessary, a selection procedure will be carried out. Places will be allocated taking into account the students' academic progress. Details will be announced on the lecture website.

- The Lab course will take place in the clean room Facilities of InnovationLab in Heidelberg. Speyerer str. 4, 69115 Heidelberg where the research laboratories of Prof. Hernandez-Sosa are located.

- The 4 th experiment will take place at KIT Campus North, Institute of Nanotechnology, in the research unit and laboratories of Prof. Jasmin Aghassi-Hagmann

Attendance of at least 80% is compulsory during the seminar course. Compulsory attendance is necessary for actively contributing to the discussion of the topics presented by all students.

T 7.98 Course: Laboratory Biomedical Engineering [T-ETIT-101934]

Responsible: Prof. Dr. Werner Nahm
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100389 - Laboratory Biomedical Engineering

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each summer term	3

Prerequisites
Passed exam of the module "Biomedizinische Messtechnik I".

Modeled Conditions
You have to fulfill one of 2 conditions:

1. The course T-ETIT-106492 - Biomedical Measurement Techniques I must have been passed.
2. The course T-ETIT-101928 - Biomedical Measurement Techniques I must have been passed.

T 7.99 Course: Laboratory Circuit Design [T-ETIT-100788]

Responsible: Prof. Dr.-Ing. Jürgen Becker
Dr.-Ing. Oliver Sander
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100518 - Laboratory Circuit Design

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each winter term	1

Events					
WT 24/25	2311638	Laboratory Circuit Design	4 SWS	Practical course / 🗣	Becker

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

7.100 Course: Laboratory FPGA Based Circuit Design [T-ETIT-100759]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100470 - Laboratory FPGA Based Circuit Design

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each term	1

Events					
WT 24/25	2312674	Laboratory FPGA Based Circuit Design	4 SWS	Practical course / 🗣	Wünsch, Kempf
ST 2025	2312674	Laboratory FPGA Based Circuit Design	4 SWS	Practical course / 🗣	Kempf, Wünsch

Legend: 🖥 Online, ❁ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.101 Course: Laboratory in Software Engineering [T-ETIT-100681]

Responsible: Prof. Dr.-Ing. Eric Sax
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100460 - Laboratory in Software Engineering

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

Prerequisites
none

T 7.102 Course: Laboratory Information Systems in Power Engineering [T-ETIT-100727]

Responsible: Prof. Dr.-Ing. Thomas Leibfried
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100415 - Laboratory Information Systems in Power Engineering

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each summer term	1

Prerequisites
none

T 7.103 Course: Laboratory Lighting Technology [T-ETIT-104726]

Responsible: Prof. Dr. Cornelius Neumann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-102356 - Laboratory Lighting Technology

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each term	1

Events					
WT 24/25	2313715	Laboratory Lighting Technology	4 SWS	Practical course / 🗣	Neumann, Trampert
ST 2025	2313715	Laboratory Lighting Technology	4 SWS	Practical course / 🗣	Trampert, Neumann

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

7.104 Course: Laboratory Mechatronic Measurement Systems [T-ETIT-106854]

Responsible: Prof. Dr.-Ing. Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-103448 - Laboratory Mechatronic Measurement Systems

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 24/25	2302123	Laboratory Mechatronic Measurement Systems	4 SWS	Practical course / 🗣	Heizmann, Steffens

Legend: 🖥 Online, ✱ Blended (On-Site/Online), 🗣 On-Site, x Cancelled

Competence Certificate
The success control is carried out in the form of a written test of 120 minutes. If there are fewer than 20 candidates, an oral exam of around 20 minutes can alternatively take place. The module grade is the grade of the written or oral exam.

Prerequisites
none

Recommendation
Knowledge from the lectures "Metrology" or "Metrology in Mechatronics" and "Manufacturing Metrology" as well as basic knowledge of programming (e.g. in Matlab, C / C ++) are helpful.

Annotation
Annotations

The submission of the protocols of all experiments is required for admission to the examination. The quality of the protocols is assessed; for the admission to the exam, the quality must be acceptable.

Attendance of all laboratory dates including the introductory event is required. Already in the event of a single unexcused absence, admission to the examination will not be granted.

T 7.105 Course: Laboratory Mechatronics [T-MACH-105370]

Responsible: Prof. Dr. Veit Hagenmeyer
Prof. Dr.-Ing. Christoph Stiller

Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-102699 - Laboratory Mechatronics

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	4	pass/fail	Each winter term	4

Events					
WT 24/25	2105014	Laboratory mechatronics	3 SWS	Practical course / 🗣	Hagenmeyer, Stiller, Chen, Orth, Klemp

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Competence Certificate
The laboratory course is offered exclusively as ungraded course work. The assessment consists of a group colloquium at the beginning of the individual specialization phases (Part 1). In addition, a robot control system for a pick-and-place task must be successfully implemented in the group phase (Part 2).

Prerequisites
None

T 7.106 Course: Laboratory Modern Software Tools in Power Engineering [T-ETIT-110898]

Responsible: Prof. Dr.-Ing. Thomas Leibfried
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105402 - Laboratory Modern Software Tools in Power Engineering

Type	Credits	Grading scale	Recurrence	Expansion	Version
Examination of another type	6	Grade to a third	Each summer term	1 terms	1

Competence Certificate
The control of success is carried out in the form of a total of 3 grades of the experiments (1 grade per experiment) in accordance with § 4 Paragraph 2 No. 3 SPO-Master2015-016, 2018

Recommendation
Basic knowledge from the lectures High Voltage Engineering, Calculation of Electrical Grids and Electric Power Transmission and Grid Control. PC knowledge and English skills.

T 7.107 Course: Laboratory Nanotechnology [T-ETIT-100765]

Responsible: Prof. Dr. Ulrich Lemmer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100478 - Laboratory Nanotechnology

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each term	1

Events					
WT 24/25	2313714	Laboratory Nanotechnology	4 SWS	Practical course / 🗣	Lemmer, Trampert
ST 2025	2313714	Laboratory Nanotechnology	4 SWS	Practical course / 🗣	Trampert, Lemmer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.108 Course: Laboratory Optoelectronics [T-ETIT-100764]

Responsible: Dr.-Ing. Klaus Trampert
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100477 - Laboratory Optoelectronics

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each term	1

Events					
WT 24/25	2313712	Laboratory Optoelectronics	4 SWS	Practical course / 🗣	Kling, Trampert
ST 2025	2313712	Laboratory Optoelectronics	4 SWS	Practical course / 🗣	Trampert, Kling

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.109 Course: Laboratory Solar Energy [T-ETIT-104686]

Responsible: Dr.-Ing. Klaus Trampert
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-102350 - Laboratory Solar Energy

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each term	1

Events					
WT 24/25	2313716	Laboratory Solar Energy	4 SWS	Practical course / 🗣	Richards, Trampert, Paetzold
ST 2025	2313708	Laboratory Solar Energy	4 SWS	Practical course / 🗣	Trampert, Paetzold, Richards

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.110 Course: Laser Metrology [T-ETIT-100643]

Responsible: Prof. Dr. Marc Eichhorn
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100434 - Laser Metrology

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Competence Certificate
The exam will be taken as an oral examination (about 20 minutes). The individual appointments for examination are offered at two previously determined dates.

Prerequisites
none

T 7.111 Course: Laser Physics [T-ETIT-100741]

Responsible: Prof. Dr. Marc Eichhorn
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100435 - Laser Physics

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2301480	Laserphysics	2 SWS	Lecture / 🔀	Eichhorn
WT 24/25	2301481	Exercise for 2301480 Laserphysics	1 SWS	Practice / 🔀	Eichhorn

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The exam will be taken as an oral examination (about 20 minutes). The individual appointments for examination are offered at two previously determined dates.

Prerequisites
none

T 7.112 Course: Liberalised Power Markets [T-WIWI-107043]

Responsible: Prof. Dr. Wolf Fichtner
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-105403 - Liberalised Power Markets

Type	Credits	Grading scale	Recurrence	Version
Written examination	5,5	Grade to a third	Each winter term	2

Events					
WT 24/25	2581998	Liberalised Power Markets	2 SWS	Lecture / 🗣	Fichtner
WT 24/25	2581999	Übungen zu Liberalised Power Markets	2 SWS	Practice / 🗣	Signer, Fichtner, Beranek

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment consists of a written exam (60 minutes) (following §4(2) of the examination regulation). The exam takes place in every semester. Re-examinations are offered at every ordinary examination date. Depending on the respective pandemic situation, the exam may be offered as an open book exam (alternative exam assessment, following §4(2), 3 of the examination regulation).

Recommendation
None

T 7.113 Course: Light and Display Engineering [T-ETIT-100644]

Responsible: Dr.-Ing. Rainer Kling
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100512 - Light and Display Engineering

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2313747	Light and Display Engineering	2 SWS	Lecture / ✕	Kling
WT 24/25	2313749	Übungen zu 2313747 Light and Display Engineering	1 SWS	Practice / ✕	Kling

Legend: Online, Blended (On-Site/Online), On-Site, ✕ Cancelled

Prerequisites
none

T 7.114 Course: Lighting Design - Theory and Applications [T-ETIT-100997]

Responsible: Dr.-Ing. Rainer Kling
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100577 - Lighting Design - Theory and Applications

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2313751	Lighting Design - Theory and Applications	2 SWS	Seminar / ✕	Kling

Legend: Online, Blended (On-Site/Online), On-Site, ✕ Cancelled

Prerequisites
none

7.115 Course: Lighting Engineering [T-ETIT-100772]

Responsible: Prof. Dr. Cornelius Neumann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100485 - Lighting Engineering

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2313739	Lighting Engineering	2 SWS	Lecture / 🗣	Neumann
WT 24/25	2313741	Lighting Engineering (Tutorial to 2313739)	1 SWS	Practice	Neumann

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.116 Course: Localization of Mobile Agents [T-INFO-101377]

Responsible: Prof. Dr.-Ing. Uwe Hanebeck
Organisation: KIT Department of Informatics
Part of: M-INFO-100840 - Localization of Mobile Agents

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

T 7.117 Course: Low Power Design [T-INFO-101344]

Responsible: Prof. Dr.-Ing. Jörg Henkel
Organisation: KIT Department of Informatics
Part of: M-INFO-100807 - Low Power Design

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Competence Certificate
The assessment is carried out as an oral examination (§ 4 Abs. 2 Nr. 2 SPO) lasting 20 minutes.

Prerequisites
None.

Recommendation
Module **Design and Architectures for Embedded Systems**
Basic knowledge from the module **Optimisation and Synthesis of Embedded Systems** is helpful for understanding this lecture but is not essential.
The lecture is equally suitable for computer science students and electrical engineering students.

T 7.118 Course: Machine Learning 1 - Basic Methods [T-WIWI-106340]

Responsible: Prof. Dr.-Ing. Johann Marius Zöllner
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-105003 - Machine Learning 1

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	4

Events					
WT 24/25	2511500	Machine Learning 1 - Fundamental Methods	2 SWS	Lecture / 🗣	Zöllner
WT 24/25	2511501	Exercises to Machine Learning 1 - Fundamental Methods	1 SWS	Practice / 🗣	Zöllner, Polley, Fechner, Daaboul

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Depending on further pandemic developments, the exam will be offered either as an open-book exam, or as a written exam (60 min):

The exam takes place every semester and can be repeated at every regular examination date.

A grade bonus can be earned by successfully completing practice exercises. If the grade of the written exam is between 4.0 and 1.3, the bonus improves the grade by up to one grade level (0.3 or 0.4). Details will be announced in the lecture.

Prerequisites
None.

T 7.119 Course: Machine Learning 2 – Advanced Methods [T-WIWI-106341]

Responsible: Prof. Dr.-Ing. Johann Marius Zöllner
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-105006 - Machine Learning 2

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each summer term	4

Events					
ST 2025	2511502	Machine Learning 2 - Advanced Methods	2 SWS	Lecture / 🗣	Zöllner, Fechner, Polley, Stegmaier
ST 2025	2511503	Exercises for Machine Learning 2 - Advanced Methods	1 SWS	Practice / 🗣	Zöllner, Fechner, Polley, Stegmaier

Legend: 🖥 Online, ❂ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Depending on further pandemic developments, the exam will be offered either as an open-book exam, or as a written exam (60 min).

The exam takes place every semester and can be repeated at every regular examination date.

Prerequisites
None.

T 7.120 Course: Machine Learning and Optimization in Communications [T-ETIT-110123]

Responsible: Prof. Dr.-Ing. Laurent Schmalen
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-104988 - Machine Learning and Optimization in Communications

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	4	Grade to a third	Each summer term	1 terms	3

Competence Certificate
Written examination of 120 minutes.

Prerequisites
Knowledge of basic engineering mathematics including integral transformations and probability theory as well as basic knowledge of communications engineering.

Recommendation
Previous visit to the lecture "Telecommunications I" and "Probability Theory" is recommended. Knowledge from the lectures "Applied Information Theory" and "Measurement Engineering" are helpful.

T 7.121 Course: Machine Learning and Optimization in Energy Systems [T-WIWI-113073]

Responsible: Prof. Dr. Wolf Fichtner
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-106604 - Machine Learning and Optimization in Energy Systems

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each winter term	4

Events					
WT 24/25	2581050	Machine Learning and Optimization in Energy Systems	3 SWS	Lecture / Practice (/ 🗣	Dengiz, Yilmaz

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, x Cancelled

Competence Certificate

The assessment of this course is a written examination (60 min) or an oral exam (30 min) depending on the number of participants. A bonus can be acquired through successful participation in the computer exercise. If the grade of the written examination is between 4.0 and 1.3, the bonus improves the grade by one grade level (0.3 or 0.4). The exact criteria for awarding a bonus will be announced at the beginning of the exercises.

T 7.122 Course: Machine Tools and High-Precision Manufacturing Systems [T-MACH-110963]

Responsible: Prof. Dr.-Ing. Jürgen Fleischer
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-101286 - Machine Tools and Industrial Handling

Type	Credits	Grading scale	Recurrence	Version
Oral examination	9	Grade to a third	Each winter term	2

Events					
WT 24/25	2149910	Machine Tools and High-Precision Manufacturing Systems	6 SWS	Lecture / Practice (/ 🗣	Fleischer

Legend: 🖥 Online, ❂ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Oral exam (approx. 45 minutes)

Prerequisites
T-MACH-102158 - Machine Tools and Industrial Handling must not be commenced.
T-MACH-109055 - Machine Tools and Industrial Handling must not be commenced.
T-MACH-110962 - Machine Tools and High-Precision Manufacturing Systems must not be commenced.

7.123 Course: Machine Vision [T-MACH-105223]

Responsible: Dr. Martin Lauer
Prof. Dr.-Ing. Christoph Stiller

Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-101923 - Machine Vision

Type	Credits	Grading scale	Recurrence	Version
Written examination	8	Grade to a third	Each winter term	2

Events					
WT 24/25	2137308	Machine Vision	4 SWS	Lecture / Practice (/ 🗣	Lauer, Merkert

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Type of Examination: written exam

Duration of Examination: 60 minutes

Prerequisites
None

T 7.124 Course: Measurement Technology [T-ETIT-112147]

Responsible: Prof. Dr.-Ing. Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105982 - Measurement Technology

Type	Credits	Grading scale	Version
Written examination	5	Grade to a third	1

Events					
WT 24/25	2302117	Measurement Technology	2 SWS	Lecture / 🗘	Heizmann
WT 24/25	2302118	Exercise for 2302117 Measurement Technology	1 SWS	Practice / 🗣	Heizmann, Schmerbeck

Legend: 🖥 Online, 🗘 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The examination takes place in form of a written examination lasting 120 minutes. The module grade is the grade of the written examination.

Prerequisites
T-ETIT-101937 – Messtechnik (German version) must not have started.

7.125 Course: Medical Image Processing for Guidance and Navigation [T-ETIT-113425]

Responsible: Prof. Dr.-Ing. Maria Francesca Spadea
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106672 - Medical Image Processing for Guidance and Navigation

Type	Credits	Grading scale	Recurrence	Version
Oral examination	9	Grade to a third	Each winter term	2

Events					
WT 24/25	2305297	Medical Image Processing for Guidance and Navigation	6 SWS	Lecture / Practice (/ 🗣	Spadea, Raggio, Riggio, Arndt, Hopp

Legend: 🖥 Online, ❂ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The examination takes place within the framework of an oral overall examination of approx. 30 minutes about the lecture including a presentation and discussion of the project developed during the course. The overall impression is rated.

The module grade is the grade of the oral exam.

A bonus can be earned for submitting homework that will be provided during the lecture time.

The exact criteria for awarding a bonus will be announced at the beginning of the lecture period. If the grade in the oral exam is between 4.0 and 1.3, the bonus improves the grade by 0.3 or 0.4.

Bonus points do not expire and are retained for any examinations taken at a later date.

Prerequisites
none

T 7.126 Course: Medical Imaging Technology [T-ETIT-113625]

Responsible: Prof. Dr.-Ing. Maria Francesca Spadea
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106778 - Medical Imaging Technology

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each summer term	1

Competence Certificate
The examination takes place in form of a written examination lasting 90 minutes. The course grade is the grade of the written exam.

Prerequisites
none

T 7.127 Course: Medical Imaging Technology II [T-ETIT-113421]

Responsible: Prof. Dr.-Ing. Maria Francesca Spadea
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106670 - Medical Imaging Technology II

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	1

Competence Certificate
The examination takes place in form of a written examination lasting 90 minutes. The course grade is the grade of the written exam.

Prerequisites
none

T 7.128 Course: Medical Measurement Technology [T-ETIT-113607]

Responsible: Prof. Dr. Werner Nahm
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106679 - Medical Measurement Technology

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 24/25	2305269	Medical Measurement Techniques	4 SWS	Lecture / 🗣	Nahm

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment takes place in the form of a written examination lasting 120 min. and 120 points.

The module grade is the grade of the written exam.

Bonus points can also be awarded for a student presentation within the lecture. Bonus points are awarded as follows:

- solving bonus tasks is voluntary.
- students register in ILIAS in groups of max. 3 participants for a bonus task.
- the solution to the bonus task must be entered in ILIAS by the specified submission deadline.
- the solutions are read by the lecture assistants and, if necessary, corrected and approved.
- the groups present their solutions in the lecture (20 min).
- the bonus points are awarded individually to each student by the lecturer on the basis of the written solution and the presentation.
- Each student can earn a maximum of 6 bonus points.
- Bonus points can only be earned once.

The bonus points are credited as follows:

- A maximum of 6 points can be credited to the exam result for the passed bonus task.
- The grade can thus be improved by a maximum of one grade step.
- The total number of points remains limited to 120 points. The bonus points are only taken into account if the exam is passed. Bonus points do not expire and are retained for any examinations taken at a later date.

Prerequisites
none

T 7.129 Course: Microactuators [T-MACH-101910]

Responsible: Prof. Dr. Manfred Kohl
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-100487 - Microactuators

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each summer term	2

Competence Certificate
written exam, 60 min.

Prerequisites
none

T 7.130 Course: Microenergy Technologies [T-MACH-105557]

Responsible: Prof. Dr. Manfred Kohl
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-102714 - Microenergy Technologies

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each summer term	1

Competence Certificate
Oral examination (30 Min.)

Prerequisites
none

T 7.131 Course: Microsystem Technology [T-ETIT-100752]

Responsible: Prof. Dr. Wilhelm Stork
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100454 - Microsystem Technology

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2311625	Microsystem Technology	2 SWS	Lecture / 🔀	Stork

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Achievement will be examined in an oral examination (approx. 20 minutes).

Prerequisites
none

T 7.132 Course: Microwave Engineering [T-ETIT-100802]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100535 - Microwave Engineering

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each term	1

Events					
WT 24/25	2308407	Microwave Engineering	2 SWS	Lecture / 🗣	Pauli
WT 24/25	2308409	Tutorial for 2308407 Microwave Engineering	1 SWS	Practice / 🗣	Bhutani

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

Annotation
WS: german

SS: english

The exam is in each semester and for every student bilingual.

T 7.133 Course: Microwave Engineering Lab [T-ETIT-110789]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105300 - Microwave Engineering Lab

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each term	1

Events					
WT 24/25	2308415	Microwave Engineering Lab	4 SWS	Practical course / 🗣	Pauli

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
To prepare the laboratory tests, each laboratory group has to do some homework together before the experiment and hand in a simple copy to the supervisor immediately before the start of the experiment. The tasks for the experiment as such are processed and logged during the implementation. The protocol should be handed over to the supervisor immediately after the experiment has been carried out. Before each experiment, there is a written exam or oral (approx. 20 min., No aids) the content of the experiment.

Prerequisites
none

Recommendation
Knowledge of microwave measurement technology and RF components and systems is helpful.

T 7.134 Course: Microwave Engineering Lab [T-ETIT-113938]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106973 - Microwave Engineering Lab

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each term	1

Competence Certificate
To prepare the laboratory tests, each laboratory group has to do some homework together before the experiment and hand in a simple copy to the supervisor immediately before the start of the experiment. The tasks for the experiment as such are processed and logged during the implementation. The protocol should be handed over to the supervisor immediately after the experiment has been carried out. Before each experiment, there is a written exam or oral (approx. 20 min., No aids) the content of the experiment.

The grade for the test execution consists of the preparation, the protocol and the written or oral learning objective control for the respective test. The final grade for the entire laboratory results from the overall impression of the performance. Students who appear unprepared for the respective experiment are not allowed to take part in the experiment. The attempt must be repeated at another time.

Prerequisites
none

Recommendation
Knowledge of microwave measurement technology and RF components and systems is helpful.

T 7.135 Course: Microwave Module Design [T-ETIT-111375]

Responsible: Dr. Thomas Geist
Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105701 - Microwave Module Design

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Each winter term	1 terms	1

Events					
WT 24/25	2308426	Entwurf von Mikrowellenmodulen	2 SWS	Lecture / 🗣	Geist

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, x Cancelled

Competence Certificate
The success control is carried out as part of an oral overall examination (approx. 20 minutes) of the selected courses, which is in total meet the minimum requirement for LP.

Prerequisites
none

Recommendation
Knowledge of the basics of radio frequency technology and communications technology is helpful.

T 7.136 Course: Microwaves Measurement Techniques [T-ETIT-100733]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100424 - Microwaves Measurement Techniques

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each summer term	4

Prerequisites
none

T 7.137 Course: Miniaturized passive microwave circuits [T-ETIT-108389]

Responsible: Dr.-Ing. Stefan Wünsch
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-101968 - Miniaturized Passive Microwave Circuits

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	2

Prerequisites
none

T 7.138 Course: Mixed-Signal IC Design [T-ETIT-111845]

Responsible: Prof. Dr.-Ing. Ahmet Cagri Ulusoy
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105893 - Mixed-Signal IC Design

Type	Credits	Grading scale	Version
Oral examination	3	Grade to a third	1

Competence Certificate
The success criteria will be determined by an oral examination (30 min.)

T 7.139 Course: MMIC Design Laboratory [T-ETIT-111006]

Responsible: Prof. Dr.-Ing. Ahmet Cagri Ulusoy
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105464 - MMIC Design Laboratory

Type	Credits	Grading scale	Recurrence	Expansion	Version
Examination of another type	6	Grade to a third	Each term	1 terms	1

Events					
WT 24/25	2308438	MMIC Design Laboratory	4 SWS	Practical course / Blended	Ulusoy

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
The written report and the oral presentation are used to mark the course. The overall impression is assessed.

T 7.140 Course: Mobile Communications [T-ETIT-112127]

Responsible: Prof. Dr.-Ing. Peter Rost
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105971 - Mobile Communications

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	1

Events					
WT 24/25	2310523	Mobile Communications	2 SWS	Lecture / 🔀	Rost
WT 24/25	2310524	Tutorial for 2310523 Mobile Communications	1 SWS	Practice / 🔀	Rost

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The success control takes place in the form of an oral examination lasting 25 minutes. Before the examination, there is a preparation phase of 15 minutes in which preparatory tasks are solved.

Prerequisites
none

T 7.141 Course: Mobile Communications II [T-ETIT-112679]

Responsible: Prof. Dr.-Ing. Peter Rost
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106244 - Mobile Communications II

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Each summer term	1 terms	1

Competence Certificate
The success control takes place in the form of an oral examination lasting 25 minutes. Before the examination, there is a preparation phase of 15 minutes in which preparatory tasks are solved.

Prerequisites
none

T 7.142 Course: Mobile Communications Workshop [T-ETIT-113063]

Responsible: Prof. Dr.-Ing. Peter Rost
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106456 - Mobile Communications Workshop

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4	Grade to a third	Each term	1

Events					
WT 24/25	2310513	Mobile Communications Workshop	2 SWS	Practical course / 🗣	Rost
ST 2025	2310522	Mobile Communications Workshop	2 SWS	Practical course / 🗣	Rost

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, x Cancelled

Competence Certificate
The success controll takes place in the form of other types of examination. The exam consists of report covering the individual experiments. The reports are evaluated as a whole. *The grade of the module corresponds to the grade given for all reports (no individual grades for each report are given).*

Prerequisites
none

T 7.143 Course: Modeling and Simulation [T-MACH-105297]

Responsible: Prof. Dr.-Ing. Kai Furmans
Prof. Dr.-Ing. Marcus Geimer
Prof. Dr.-Ing. Luise Kärger
Prof. Dr.-Ing. Carsten Proppe

Organisation: KIT Department of Mechanical Engineering

Institute of Thermal Turbomachinery

Part of: M-MACH-102592 - Modeling and Simulation

Type	Credits	Grading scale	Recurrence	Version
Written examination	7	Grade to a third	Each winter term	1

Events					
WT 24/25	2185227	Modelling and Simulation	2 SWS	Lecture / 🗣	Proppe, Furmans, Geimer, Kärger
WT 24/25	2185228	Modeling and Simulation	2 SWS	Practice / 🗣	Proppe, Furmans, Kärger, Geimer, Höllig

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment consists of a 180 minutes written examination.

Prerequisites
none

Annotation
Last held in winter semester 24/25. From winter semester 25/26, this course will no longer be offered. It will be replaced by two new courses, one of which (Numerical Methods for Engineering Applications, 4 CP, starting summer semester 25) will always be offered in the summer semester and a second course (3 CP) will always be offered in the winter semester.

T 7.144 Course: Modelling and Simulation of Electrochemical Systems [T-ETIT-100781]

Responsible: Dr.-Ing. Andre Weber
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100508 - Modelling and Simulation of Electrochemical Systems

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Events					
ST 2025	2304217	Modellbildung elektrochemischer Systeme	2 SWS	Lecture / 🗣	Weber

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.145 Course: Modern Radio Systems Engineering [T-ETIT-100735]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100427 - Modern Radio Systems Engineering

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each summer term	1

Prerequisites
none

T 7.146 Course: Modern VLSI Technologies [T-ETIT-113864]

Responsible: Prof. Dr. Jasmin Aghassi-Hagmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106921 - Modern VLSI Technologies

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

Competence Certificate
Success control takes place in form of an oral examination with a duration of approx. 20 minutes. Exercises have to be sucessfully completed before the exam is taken. Further details will be provided at the beginning of the course.
The module grade is the grade of the oral exam.

7.147 Course: Nano- and Quantum Electronics [T-ETIT-111232]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105604 - Nano- and Quantum Electronics

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	6	Grade to a third	Each summer term	1 terms	1

Events					
ST 2025	2312668	Nano- and Quantum Electronics	3 SWS	Lecture / 🗣	Kempf
ST 2025	2312670	Tutorial for 2312668 Nano- and Quantum Electronics	1 SWS	Practice / 🗣	Wünsch

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment of success takes place in the form of a written examination lasting 120min. The grade corresponds to the result of the written examination.

Prerequisites
none

Recommendation
Successful completion of the modules "Superconductivity for Engineers" and „Einführung in die Quantentheorie für Elektrotechniker“ is recommended.

T 7.148 Course: Navigation and Localization Techniques [T-ETIT-111829]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105881 - Navigation and Localization Techniques

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Events					
ST 2025	2308440	Navigation and Localization Techniques	2 SWS	Lecture / 🗣	Sand

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The success control is carried out as part of an oral overall examination (approx. 20 minutes) of the selected courses, which in total meet the minimum requirement for LP.

T 7.149 Course: NMR Methods for Product and Process Analysis [T-CIWVT-111843]

Responsible: apl. Prof. Dr. Gisela Guthausen
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-105890 - NMR Methods for Product and Process Analysis

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2245130	NMR for Engineers	2 SWS	Lecture / 🗣	Guthausen

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Learning control is an oral examination with a duration of about 30 minutes.

Prerequisites
None.

T 7.150 Course: Nonlinear Control Systems [T-ETIT-100980]

Responsible: Dr.-Ing. Mathias Kluwe
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100371 - Nonlinear Control Systems

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	1

Prerequisites
none

T 7.151 Course: Nonlinear Optics [T-ETIT-101906]

Responsible: Prof. Dr.-Ing. Christian Koos
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100430 - Nonlinear Optics

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	2

Prerequisites
none

T 7.152 Course: Numerical Methods - Exam [T-MATH-111700]

Responsible: apl. Prof. Dr. Peer Kunstmann
TT-Prof. Dr. Xian Liao
Prof. Dr. Wolfgang Reichel

Organisation: KIT Department of Mathematics

Part of: M-MATH-105831 - Numerical Methods
M-MATH-106972 - Numerical Methods with Programming Practice

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each summer term	1

Events					
ST 2025	0180300	Numerical Methods (Electrical Engineering, Meteorology, Remote Sensing, Geoinformatics)	2 SWS	Lecture	Tolksdorf
ST 2025	0180400	Tutorial for 0180300	1 SWS	Practice	Tolksdorf

Competence Certificate
Success control takes the form of a written examination (120 minutes).

Prerequisites
none

T 7.153 Course: Numerical Methods - Workshop [T-MATH-113937]

Responsible: apl. Prof. Dr. Peer Kunstmann
TT-Prof. Dr. Xian Liao
Prof. Dr. Wolfgang Reichel

Organisation: KIT Department of Mathematics

Part of: M-MATH-106972 - Numerical Methods with Programming Practice

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	1	pass/fail	Each summer term	1

Competence Certificate
Successful participation in the workshop is confirmed by signing the attendance sheet provided at each practice session.

Prerequisites
None

T 7.154 Course: Numerical Methods for Partial Differential Equations [T-ETIT-104595]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-102311 - Numerical Methods for Partial Differential Equations

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each summer term	2

Events					
ST 2025	2303600	Numerical Methods for Partial Differential Equations	2 SWS	Lecture / 🗣	Nagato-Plum
ST 2025	2303601	Übung zu 2303180 Numerische Methoden für partielle Differentialgleichungen	1 SWS	Practice / 🗣	Nagato-Plum

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

7.155 Course: Optical Design Lab [T-ETIT-100756]

Responsible: Prof. Dr. Wilhelm Stork
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100464 - Optical Design Lab

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	2

Prerequisites
none

T 7.156 Course: Optical Engineering [T-ETIT-100676]

Responsible: Prof. Dr. Wilhelm Stork
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100456 - Optical Engineering

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2311629	Optical Engineering	2 SWS	Lecture / 🧩	Stork
WT 24/25	2311631	Tutorial for 2311629 Optical Engineering	1 SWS	Practice / 🧩	Fan

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Achievement will be examined in an oral examination (approx. 20 minutes)

Prerequisites
none

T 7.157 Course: Optical Engineering and Machine Vision [T-ETIT-113941]

Responsible: Prof. Dr.-Ing. Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106974 - Optical Engineering and Machine Vision

Type	Credits	Grading scale	Version
Written examination	6	Grade to a third	1

Competence Certificate
The examination takes place in form of a written examination lasting 90 minutes.

The module grade is the grade of the written examination.

Prerequisites
none

T 7.158 Course: Optical Networks and Systems [T-ETIT-106506]

Responsible: Prof. Dr.-Ing. Sebastian Randel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-103270 - Optical Networks and Systems

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	2

Events					
WT 24/25	2309470	Optical Networks and Systems	2 SWS	Lecture / 🗣	Randel
WT 24/25	2309471	Tutorial for 2309470 Optical Networks and Systems	1 SWS	Practice / 🗣	Randel, N.N.

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.159 Course: Optical Systems in Medicine and Life Science [T-ETIT-106462]

Responsible: Prof. Dr. Werner Nahm
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-103252 - Optical Systems in Medicine and Life Science

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	3

Events					
WT 24/25	2305292	Optical Systems in Medicine and Life Science	2 SWS	Lecture / ✕	Hoffmann, Nahm

Legend: Online, Blended (On-Site/Online), On-Site, ✕ Cancelled

Competence Certificate
Written exam (60 minutes)

Prerequisites
Only one out of the two modules "M-ETIT-100552 - Optische Systeme für Medizintechnik und Life Sciences" and "M-ETIT-103252 - Optical Systems in Medicine and Life Science" is allowed.

Recommendation
Good understanding of optics and optoelectronics.

Annotation
Language English

T 7.160 Course: Optical Technologies for Automotive Applications [T-ETIT-100773]

Responsible: Prof. Dr. Cornelius Neumann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100486 - Optical Technologies for Automotive Applications

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Prerequisites
none

T 7.161 Course: Optical Transmitters and Receivers [T-ETIT-100639]

Responsible: Prof. Dr. Wolfgang Freude
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100436 - Optical Transmitters and Receivers

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	2

Events					
WT 24/25	2309460	Optical Transmitters and Receivers	2 SWS	Lecture / 🗣	Freude
WT 24/25	2309461	Tutorial for 2309460 Optical Transmitters and Receivers	2 SWS	Practice / 🗣	Freude, N.N.

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.162 Course: Optical Waveguides and Fibers [T-ETIT-101945]

Responsible: Prof. Dr.-Ing. Christian Koos
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100506 - Optical Waveguides and Fibers

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2309464	Optical Waveguides and Fibers	2 SWS	Lecture / 🗣	Koos, N.N., Bao
WT 24/25	2309465	Tutorial for 2309464 Optical Waveguides and Fibers	1 SWS	Practice / 🗣	Koos, N.N.

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.163 Course: Optimal Control and Estimation [T-ETIT-104594]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-102310 - Optimal Control and Estimation

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Prerequisites
none

T 7.164 Course: Optimization and Synthesis of Embedded Systems (ES1) [T-INFO-101367]

Responsible: Prof. Dr.-Ing. Jörg Henkel
Organisation: KIT Department of Informatics
Part of: M-INFO-100830 - Optimization and Synthesis of Embedded Systems (ES1)

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2424143	Optimisation and synthesis of embedded systems (ES1)	2 SWS	Lecture / 🗣	Siddhu, Henkel

Legend: 🖥 Online, ⚃ Blended (On-Site/Online), 🗣 On-Site, x Cancelled

Competence Certificate
The assessment is carried out as an oral examination (§ 4 Abs. 2 Nr. 2 SPO) lasting 20 minutes.

Prerequisites
The prerequisites, if any, are explained in more detail in the module description.

Recommendation
Knowledge of computer structures is helpful.

T 7.165 Course: Optimization of Dynamic Systems [T-ETIT-100685]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100531 - Optimization of Dynamic Systems

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	1

Events					
WT 24/25	2303183	Optimization of Dynamic Systems	2 SWS	Lecture /	Hohmann
WT 24/25	2303185	Optimization of Dynamic Systems (Tutorial to 2303183)	1 SWS	Practice /	Hess
WT 24/25	2303851	Accompanying group tutorial for 2303183 Optimization of Dynamic Systems	1 SWS	Tutorial (/	Hess

Legend: Online, Blended (On-Site/Online), On-Site, × Cancelled

Competence Certificate
The assessment consists of a written exam (120 min) taking place in the recess period.

Prerequisites
none

T 7.166 Course: Optoelectronic Components [T-ETIT-101907]

Responsible: Prof. Dr.-Ing. Sebastian Randel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100509 - Optoelectronic Components

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each summer term	1

Prerequisites
none

T 7.167 Course: Optoelectronic Measurement Engineering [T-ETIT-100771]

Responsible: Dr.-Ing. Klaus Trampert
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100484 - Optoelectronic Measurement Engineering

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Events					
ST 2025	2313736	Optoelectronic Measurement Engineering	2 SWS	Lecture / 🗣	Trampert

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.168 Course: Optoelectronics [T-ETIT-100767]

Responsible: Prof. Dr. Ulrich Lemmer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100480 - Optoelectronics

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each summer term	3

Events					
WT 24/25	2313726	Optoelectronics	2 SWS	Lecture / ✕	Lemmer
WT 24/25	2313728	Übungen zu 2313726 Optoelektronik	1 SWS	Practice / ✕	Lemmer

Legend: Online, Blended (On-Site/Online), On-Site, ✕ Cancelled

Competence Certificate
The success check is carried out in the context of a written exam (90 minutes).

Prerequisites
none

Recommendation
Knowledge of solid state electronics

T 7.169 Course: Packaging and Interconnects for Power Electronic Systems [T-ETIT-104518]

Responsible: Dr. Thomas Blank
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-102200 - Packaging and Interconnects for Power Electronic Systems

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2306349	Packaging and Interconnects for Power Electronic Systems	2 SWS	Lecture / 🗣	Blank

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.170 Course: Pattern Recognition [T-INFO-101362]

Responsible: Prof. Dr.-Ing. Jürgen Beyerer
Tim Zander

Organisation: KIT Department of Informatics

Part of: M-INFO-100825 - Pattern Recognition

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each summer term	2

Events					
ST 2025	24675	Pattern Recognition	4 SWS	Lecture / Practice (/	Beyerer

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

7.171 Course: Photometry and Radiometry [T-ETIT-100789]

Responsible: Dr.-Ing. Klaus Trampert
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100519 - Photometry and Radiometry

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2313727	Photometry and Radiometry	2 SWS	Lecture / 🗣	Trampert

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.172 Course: Photonic Integrated Circuit Design and Applications [T-ETIT-111896]

Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105914 - Photonic Integrated Circuit Design and Applications

Type	Credits	Grading scale	Version
Examination of another type	6	Grade to a third	1

Competence Certificate

- Part 1 – Solutions of problem sets: We will grade your solutions of the various problem sets and design projects. To this end, please upload your solution via the online teaching platform of your respective institution (see above) before the respective deadline. Please merge all pages into a single pdf file, and please use a scanner. Smartphone made snapshots are often illegible, and in this case your solutions cannot not be evaluated. In case there are any technical difficulties with the platforms, you may also submit your solutions by e-mail to picda@ipq.kit.edu before the respective deadline.
- Part 2 - Presentation of one pre-assigned problem set: At the beginning of the term, design projects will be pre-assigned to groups of participants. Each of these groups will explain their approach and results to lecturers and peer students in a short presentation (approx. 15 min), followed by approx. 10 min of public discussion with peer students and professors, and an individual private interview of each group member (approx. 10 min per person).

The overall impression is rated.

Prerequisites
none

T 7.173 Course: Photonics and Communications Lab [T-ETIT-109173]

Responsible: Prof. Dr.-Ing. Christian Koos
Prof. Dr.-Ing. Sebastian Randel

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: M-ETIT-104485 - Photonics and Communications Lab

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each summer term	1

T 7.174 Course: Photovoltaics [T-ETIT-101939]

Responsible: Prof. Dr.-Ing. Michael Powalla
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100513 - Photovoltaics

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each summer term	2

Prerequisites
"M-ETIT-100524 - Solar Energy" must not have started.

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-ETIT-100774 - Solar Energy must not have been started.

T 7.175 Course: Physical and Data-Based Modelling [T-ETIT-111013]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105468 - Physical and Data-Based Modelling

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	2

Competence Certificate
Oral examination of approximately 20 minutes.

Prerequisites
none

T 7.176 Course: Physical Foundations of Cryogenics [T-CIWVT-106103]

Responsible: Prof. Dr.-Ing. Steffen Grohmann
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-103068 - Physical Foundations of Cryogenics

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

Competence Certificate
Learning control is an oral examination lasting approx. 30 minutes.

Prerequisites
None

T 7.177 Course: Physics, Technology and Applications of Thin Films [T-ETIT-111237]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105608 - Physics, Technology and Applications of Thin Films

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	4	Grade to a third	Each winter term	1 terms	1

Events					
WT 24/25	2312710	Physics, Technology and Application of Thin Films	2 SWS	Lecture / 🗣	Ilin
WT 24/25	2312711	Exercise for 2312710 Physics, Technology and Application of Thin Films	1 SWS	Practice / 🗣	Ilin

Legend: 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The success control takes place within the framework of an oral overall examination of approx. 20 minutes.

T 7.178 Course: Physiology and Anatomy for Biomedical Engineering [T-ETIT-111815]

Responsible: Prof. Dr. Werner Nahm
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105874 - Physiology and Anatomy for Biomedical Engineering

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 24/25	2305281	Physiology and Anatomy for Engineers I	2 SWS	Lecture / 🗣	Nahm

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The exmaniation is carried out in the form of a written test of 120 minutes.

The examination includes the contents of Physiologie und Anatomie I (offered every winter term) and Physiologie und Anatomie II (offered every summer term).

Prerequisites
The courses "T-ETIT-101932 - Physiologie und Anatomie I" und "T-ETIT-101933 - Physiologie und Anatomie II" must not been started.

Annotation
Winter/summer term:

WT: Physiologie und Anatomie I
ST: Physiologie und Anatomie II

T 7.179 Course: Plasma Sources [T-ETIT-100768]

Responsible: Prof. Dr. Wolfgang Heering
Dr.-Ing. Rainer Kling

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: M-ETIT-100481 - Plasma Sources

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2313729	Plasma Sources	3 SWS	Lecture / ✕	Kling

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.180 Course: Plastic Electronics / Polymerelectronics [T-ETIT-100763]

Responsible: Prof. Dr. Ulrich Lemmer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100475 - Plastic Electronics / Polymerelectronics

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2313709	Polymerelectronics/ Plastic Electronics	2 SWS	Lecture /	Hernandez Sosa

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
The control of success takes place within the framework of an oral overall examination (approx. 30 minutes).

Prerequisites
none

Recommendation
Knowledge of semiconductor devices

Annotation
Lecture and examination are held in German or English, as required.

7.181 Course: Power Electronic Systems in Energy Technology [T-ETIT-112286]

Responsible: Prof. Dr.-Ing. Marc Hiller
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106067 - Power Electronic Systems in Energy Technology

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Events					
WT 24/25	2306357	Power Electronic Systems in Energy applications	3 SWS	Lecture / 🗣	Hiller
WT 24/25	2306358	Power Electronic Systems in Energy Applications	1 SWS	Practice / 🧩	Hiller, Knierim

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.182 Course: Power Electronics [T-ETIT-109360]

Responsible: Prof. Dr.-Ing. Marc Hiller
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-104567 - Power Electronics

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	6	Grade to a third	Each summer term	1 terms	6

Competence Certificate
The examination takes place in form of a written examination lasting 120 minutes.

Prerequisites
none

T 7.183 Course: Power Electronics for Photovoltaics and Wind Energy [T-ETIT-104569]

Responsible: Prof. Dr.-Ing. Marc Hiller
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-102261 - Power Electronics for Photovoltaics and Wind Energy

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	2

Prerequisites
none

T 7.184 Course: Power Network [T-ETIT-100830]

Responsible: Prof. Dr.-Ing. Thomas Leibfried
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100572 - Power Network

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	2

Events					
WT 24/25	2307371	Power Network	2 SWS	Lecture / 🗣	Leibfried
WT 24/25	2307373	Tutorial for 2307371 Power Network	1 SWS	Practice / 🗣	Leibfried, Geis-Schroer

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 7.185 Course: Power System Protection and Automation [T-ETIT-113164]

Responsible: Prof. Dr.-Ing. Thomas Leibfried
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106506 - Power System Protection and Automation

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Each winter term	1 terms	1

Events					
WT 24/25	2307396	Power System Protection and Automation	2 SWS	Lecture / 🗣	Loitz

Legend: 🖥 Online, ✣ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

7.186 Course: Power Systems and Economy [T-ETIT-100725]

Responsible: Dr.-Ing. Bernd Hoferer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100413 - Power Systems and Economy

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2307383	Power Systems and Economy	2 SWS	Lecture / 🗣	Weissmüller

Legend: 🖥 Online, ❃ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.187 Course: Practical Aspects of Electrical Drives [T-ETIT-100711]

Responsible: Prof. Dr. Martin Doppelbauer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100394 - Practical Aspects of Electrical Drives

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each winter term	2

Events					
WT 24/25	2306311	Practical Aspects of Electrical Drives	2 SWS	Lecture / ✕	Brodatzki, Doppelbauer
WT 24/25	2306313	Übungen zu 2306311 Praxis elektrischer Antriebe	1 SWS	Practice / ✕	Doppelbauer

Legend: Online, Blended (On-Site/Online), On-Site, ✕ Cancelled

Prerequisites
none

Annotation
Shift from SoSe to WiSe, does not take place in WiSe24/25 and SoSe25.

T 7.188 Course: Practical Course: Smart Energy System [T-INFO-112030]

Responsible: Dr.-Ing. Simon Waczowicz
Organisation: KIT Department of Informatics
Part of: M-INFO-105955 - Practical Course: Smart Energy System

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each term	1

Competence Certificate
The assessment is carried out as an examination of another type (§ 4 Abs. 2 No. 3 SPO). A written paper must be prepared and a presentation given.

Prerequisites
None.

Recommendation
- Knowledge of the fundamentals of energy informatics is a prerequisite.
- Knowledge of the fundamentals of electrical engineering and energy technology is required.
- Knowledge of the basics of mechatronics, data analysis and signal processing is helpful.
- Knowledge of power systems or power electronics is helpful.

7.189 Course: Practical Machine Learning [T-ETIT-113426]

Responsible: Prof. Dr.-Ing. Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106673 - Practical Machine Learning

Type	Credits	Grading scale	Version
Examination of another type	5	Grade to a third	1

Events					
ST 2025	2302200	Practical Machine Learning	4 SWS	Lecture / Practice (/ 🗣	Gardi

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Success is assessed by the submission of the scientific essay and the presentation of the team project lasting approx. 30 minutes.

The module grade results from the team project accompanying the semester and the presentation of the team project. The overall impression is assessed. Further details will be provided at the beginning of the course.

Prerequisites
none

T 7.190 Course: Practical Tools for Control Engineers [T-ETIT-113628]

Responsible: Dr.-Ing. Balint Varga
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106780 - Practical Tools for Control Engineers

Type	Credits	Grading scale	Recurrence	Expansion	Version
Examination of another type	4	Grade to a third	Each winter term	1 terms	1

Events					
WT 24/25	2303210	Practical Tools for Control Engineers	2 SWS	Lecture / 🗣	Varga

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The examination takes place in form of other types of examination. It consists of an oral overall examination in the amount of 25 minutes and a homework programming task. The examination includes questions from the lecture slides and the presentation of the homework assignment. The homework must be submitted two weeks before of the oral exam. The overall impression is evaluated.

Prerequisites
none

Recommendation
The contents of the modules “Optimization of Dynamic Systems (ODS)” and “Regelung linearer Mehrgrößensysteme (RLM)” are helpful for the lecture.

T 7.191 Course: Process Analysis: Modeling, Data Mining, Machine Learning [T-ETIT-111214]

Responsible: Dr.-Ing. Christian Borchert
Prof. Dr.-Ing. Michael Heizmann

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: M-ETIT-105594 - Process Analysis: Modeling, Data Mining, Machine Learning

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Each summer term	1 terms	2

Events					
ST 2025	2302145	Process Analysis: Modeling, Data Mining, Machine Learning	2 SWS	Lecture / 🗣	Borchert

Legend: 🖥 Online, ✿ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 7.192 Course: Project Lab Cognitive Automobiles and Robots [T-WIWI-109985]

Responsible: Prof. Dr.-Ing. Johann Marius Zöllner
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-106491 - Project Lab Applied Machine Learning

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	5	Grade to a third	Each winter term	3

Events					
WT 24/25	2512501	Practical Course Cognitive automobiles and robots (Master)	3 SWS	Practical course / 🔀	Zöllner, Daaboul

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The alternative exam assessment consists of:

- a practical work
- a presentation and
- a written seminar thesis

Details of the grade formation will be announced at the beginning of the course.

Prerequisites
None

T 7.193 Course: Project Lab Machine Learning [T-WIWI-109983]

Responsible: Prof. Dr.-Ing. Johann Marius Zöllner
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-106491 - Project Lab Applied Machine Learning

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	5	Grade to a third	Each summer term	3

Events					
ST 2025	2512500	Project Lab Machine Learning	3 SWS	Practical course / Blended	Daaboul, Zöllner, Schneider

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
The alternative exam assessment consists of:

- a practical work
- a presentation and
- a written seminar thesis

Details of the grade formation will be announced at the beginning of the course.

Prerequisites
None

T 7.194 Course: Project Management in the Development of Products for Safety-Critical Applications [T-ETIT-109148]

Responsible: Dr.-Ing. Manfred Nolle
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-104475 - Project Management in the Development of Products for Safety-Critical Applications

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each winter term	3

Events					
WT 24/25	2311641	Project Management in the Development of Products for Safety-Critical Applications	2 SWS	/	Nolle
WT 24/25	2311643	Tutorial for 2311641 Project Management in the Development of Products for Safety-Critical Applications	1 SWS	Practice /	Nolle

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

T 7.195 Course: Pulsed Power Technology and Applications (Lecture) [T-ETIT-111215]

Responsible: Prof. Dr. Georg Müller
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105595 - Pulsed Power Technology and Applications (Lecture)

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Each winter term	1 terms	1

Events					
WT 24/25	2307395	Pulsed Power Technology and Applications	2 SWS	Lecture / 🗣	Müller

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The success control takes place within the scope of an overall oral examination (20 minutes).

Prerequisites
none

Annotation
Following the lecture period the oral exam is offered by appointment.

T 7.196 Course: Pulsed Power Technology and Applications (Tutorial) [T-ETIT-111216]

Responsible: Prof. Dr. Georg Müller
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105596 - Pulsed Power Technology and Applications (Tutorial)

Type	Credits	Grading scale	Recurrence	Expansion	Version
Examination of another type	5	Grade to a third	Each summer term	1 terms	1

Competence Certificate
The examination takes place in form of other types of examination. It consists of oral examination and discussioning the amount of 30 min and a written report about the results of the experiments conducted (one report per group) The overall impression is evaluated. Details will be given during the lecture.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-ETIT-111215 - Pulsed Power Technology and Applications (Lecture) must have been passed.

T 7.197 Course: Quantum Detectors and Sensors [T-ETIT-111234]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105606 - Quantum Detectors and Sensors

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	6	Grade to a third	Each winter term	1 terms	1

Events					
WT 24/25	2312706	Quantum Detectors and Sensors	3 SWS	Lecture / 🗣	Kempf
WT 24/25	2312707	Exercise for 2312706 Quantum Detectors and Sensors	1 SWS	Practice / 🗣	Ilin

Legend: 🖥 Online, 🔄 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment of success takes place in the form of a written examination lasting 120min. The grade corresponds to the result of the written examination.

Prerequisites
None

Recommendation
Successful completion of the module "Superconductivity for Engineers" is recommended.

T 7.198 Course: Quantum Engineering [T-ETIT-113909]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106954 - Quantum Engineering

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each summer term	1

Competence Certificate
The examination takes place in form of a written examination lasting 120 minutes.

The module grade is the grade of the written exam.

Prerequisites
none

T 7.199 Course: Quantum Machine Learning [T-ETIT-111838]

Responsible: Prof. Dr.-Ing. Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105889 - Quantum Machine Learning

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2302126	Quantum Machine Learning	2 SWS	Lecture / 🗣	Gardi

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

7.200 Course: Radar Systems Engineering [T-ETIT-100729]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100420 - Radar Systems Engineering

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	2

Events					
WT 24/25	2308454	Radar Systems Engineering	3 SWS	Lecture / 🗣	Zwick, Younis
WT 24/25	2308455	Rechnerübung zu 2308454 Radar Systems Engineering	1 SWS	Practice / 🧩	Bhutani

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.201 Course: Radio Frequency Integrated Circuits and Systems [T-ETIT-110358]

Responsible: Prof. Dr.-Ing. Ahmet Cagri Ulusoy
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105123 - Radio Frequency Integrated Circuits and Systems

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	2

Competence Certificate
The success criteria will be determined by an oral examination (approx. 20-30 min.)

Recommendation
The lecture materials to „Grundlagen der Hochfrequenztechnik“ and „Halbleiterbauelemente“ are recommended.

T 7.202 Course: Radio Receivers [T-ETIT-106431]

Responsible: Prof. Dr. Friedrich Jondral
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-103241 - Radio Receivers

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2310531	Radio Receivers	2 SWS	Lecture / 🗣	Jondral

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.203 Course: Radio-Frequency Electronics [T-ETIT-110359]

Responsible: Prof. Dr.-Ing. Ahmet Cagri Ulusoy
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105124 - Radio-Frequency Electronics

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	2

Events					
WT 24/25	2308503	Radio-Frequency Electronics	2 SWS	Lecture / 🗣	Ulusoy
WT 24/25	2308504	Exercise for 2308503 Radio-Frequency Electronics	1 SWS	Practice / 🧩	Kuo

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The success criteria will be determined by a written examination of 120 min.

Recommendation
Contents of the modules "Linear electrical networks" and "Electronic circuits".

T 7.204 Course: Radio-Frequency Electronics [T-ETIT-113910]

Responsible: Prof. Dr.-Ing. Ahmet Cagri Ulusoy
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106955 - Radio-Frequency Electronics

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Competence Certificate
The examination takes place in form of a written examination lasting 120 minutes.

The module grade is the grade of the written examination.

Prerequisites
none

T 7.205 Course: Real Time Control of Electrical Drives [T-ETIT-111898]

Responsible: Dr.-Ing. Andreas Liske
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105916 - Real Time Control of Electrical Drives

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Events					
WT 24/25	2306353	Real Time Control of Electrical Drives	3 SWS	Lecture / 🔀	Liske
WT 24/25	2306354	Tutorial for 2306353 Real Time Control of Electrical Drives	1 SWS	Practice / 🔀	Liske

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 7.206 Course: Refrigeration B - Foundations of Industrial Gas Processing [T-CIWVT-108914]

Responsible: Prof. Dr.-Ing. Steffen Grohmann
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-104354 - Refrigeration B - Foundations of Industrial Gas Processing

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

Competence Certificate
The examination is an oral examination with a duration of about 30 minutes (section 4 subsection 2 number 2 SPO).

Prerequisites
None

T 7.207 Course: Renewable Energy-Resources, Technologies and Economics [T-WIWI-100806]

Responsible: Prof. Dr. Patrick Jochem
Organisation: KIT Department of Economics and Management
Part of: M-WIWI-100500 - Renewable Energy-Resources, Technologies and Economics

Type	Credits	Grading scale	Recurrence	Version
Written examination	3,5	Grade to a third	Each winter term	7

Events					
WT 24/25	2581012	Renewable Energy – Resources, Technologies and Economics	2 SWS	Lecture / 🗣	Jochem

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment consists of a written exam (60 minutes, in English, answers are possible in German or English) (following §4(2) of the examination regulation). The exam takes place in every semester. Re-examinations are offered at every ordinary examination date. Depending on the respective pandemic situation, the exam may be offered as an open book exam (alternative exam assessment, following §4(2), 3 of the examination regulation).

Prerequisites
None.

T 7.208 Course: Robotics - Practical Course [T-INFO-105107]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: M-INFO-102522 - Robotics - Practical Course

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each summer term	2

Competence Certificate
The assessment is carried out as an examination of another type (§ 4 Abs. 2 No. 3 SPO). It is composed of several sub-tasks.

Prerequisites
Knowledge of the programming language C++ is required.

Recommendation
Attending the lectures Robotics I – Introduction to Robotics, Robotics II: Humanoid Robotics, Robotics III - Sensors and Perception in Robotics and Mechano-Informatics and Robotics is recommended.

T 7.209 Course: Robotics I - Introduction to Robotics [T-INFO-108014]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: M-INFO-100893 - Robotics I - Introduction to Robotics

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	2

Events					
WT 24/25	2424152	Robotics I - Introduction to Robotics		Lecture / 🗣	Asfour, Daab, Hyseni

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 120 minutes.

Prerequisites
none.

T 7.210 Course: Robotics II - Humanoid Robotics [T-INFO-105723]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: M-INFO-102756 - Robotics II - Humanoid Robotics

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	4

Competence Certificate
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 60 minutes.

Recommendation
Having visited the lectures on Robotics I - Introduction to Robotics and Mechano-Informatics and Robotics is recommended.

T 7.211 Course: Robotics III - Sensors and Perception in Robotics [T-INFO-109931]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: M-INFO-104897 - Robotics III - Sensors and Perception in Robotics

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	2

Competence Certificate
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 60 minutes.

Prerequisites
none.

Recommendation
Attending the lecture Robotics I – Introduction to Robotics is recommended.

T 7.212 Course: Safe Human-Robot-Collaboration [T-INFO-109911]

Responsible: Dr.-Ing. Johannes Kurth
Organisation: KIT Department of Informatics
Part of: M-INFO-104877 - Safe Human-Robot-Collaboration

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2400236	Safe Human-Robot-Collaboration	2 SWS	Block / 🗣	Kurth

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 7.213 Course: Satellite Communications [T-ETIT-110672]

Responsible: Prof. Dr.-Ing. Laurent Schmalen
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105272 - Satellite Communications

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Each summer term	2 terms	1

Competence Certificate
The assessment will be carried out as part of an overall oral exam (about 20 minutes).

Prerequisites
Knowledge of basic engineering mathematics including probability theory and analysis, as well as basic knowledge of communications engineering.

Recommendation
Previous attendance of the lectures "Communication Engineering I" and "Probability Theory" is recommended. Knowledge from the lecture "Communications Engineering II" can be helpful, but is not necessary

T 7.214 Course: Scientific Computing for Engineers [T-MACH-100532]

Responsible: Prof. Dr. Peter Gumbsch
Dr. Daniel Weygand

Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-105369 - Scientific Computing for Engineers

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each winter term	3

Events					
WT 24/25	2181738	Scientific computing for Engineers	2 SWS	Lecture / 🗣	Weygand, Gumbsch
WT 24/25	2181739	Exercises for Scientific Computing for Engineers	2 SWS	Practice / 🗣	Weygand

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Written exam (90 minutes)

Prerequisites
The brick can not be combined with the brick "Application of advanced programming languages in mechanical engineering" (T-MACH-105390).

T 7.215 Course: Seminar Accessibility - Assistive Technologies for Visually Impaired Persons [T-INFO-104742]

Responsible: Prof. Dr.-Ing. Rainer Stiefelhagen
Organisation: KIT Department of Informatics
Part of: M-INFO-102374 - Seminar Accessibility - Assistive Technologies for Visually Impaired Persons

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	3	Grade to a third	Each winter term	2

T 7.216 Course: Seminar Advanced Concepts for Flexible and Soft Optoelectronic Devices and Sensors [T-ETIT-113427]

Responsible: Prof. Dr. Gerardo Hernandez Sosa
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106674 - Seminar Advanced Concepts for Flexible and Soft Optoelectronic Devices and Sensors

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	1

Events					
ST 2025	2313766	Seminar Advanced Concepts for Flexible and Soft Optoelectronic Devices and Sensors	2 SWS	Seminar / 🗣	Hernandez Sosa

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The examination consists of a written journal article and an oral presentation of the student's work, both given in English. The overall impression is rated.

The module grade results of the assessment of the written paper and the oral presentation. Details will be given during the lecture.

Prerequisites
none

T 7.217 Course: Seminar Battery II [T-ETIT-110801]

Responsible: Dr.-Ing. Andre Weber
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105321 - Seminar Battery II

Type	Credits	Grading scale	Recurrence	Expansion	Version
Examination of another type	3	Grade to a third	Each term	1 terms	1

Events					
WT 24/25	2304226	Seminar Battery	2 SWS	Seminar / 🗣	Weber
ST 2025	2304226	Seminar Batteries	2 SWS	Seminar / 🗣	Weber

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.218 Course: Seminar Electrocatalysis [T-ETIT-111256]

Responsible: Prof. Dr.-Ing. Ulrike Krewer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105629 - Seminar Electrocatalysis

Type	Credits	Grading scale	Recurrence	Expansion	Version
Examination of another type	3	Grade to a third	Each term	1 terms	1

Events					
WT 24/25	2304238	Seminar Electrocatalysis	2 SWS	Seminar / 🗣	Röse
ST 2025	2304302	Seminar Elektrokatalyse	2 SWS	Seminar / 🗣	Röse

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.219 Course: Seminar Embedded Systems [T-ETIT-100753]

Responsible: Prof. Dr.-Ing. Jürgen Becker
Prof. Dr.-Ing. Eric Sax
Prof. Dr. Wilhelm Stork

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: M-ETIT-100455 - Seminar Embedded Systems

Type	Credits	Grading scale	Version
Examination of another type	4	Grade to a third	3

Events					
WT 24/25	2311627	Seminar Embedded Systems	2 SWS	Seminar / 🗣	Becker, Sax, Stork

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.220 Course: Seminar Fuel Cell II [T-ETIT-110799]

Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105322 - Seminar Fuel Cell II

Type	Credits	Grading scale	Recurrence	Expansion	Version
Examination of another type	3	Grade to a third	Each term	1 terms	1

Events					
WT 24/25	2304227	Seminar Fuel Cell	2 SWS	Seminar / 🗣	Weber
ST 2025	2304227	Seminar Fuel Cell	2 SWS	Seminar / 🗣	Weber

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Success is checked in the form of other types of examinations. The success control takes place in the form of a written elaboration and a seminar presentation. More details will be given in the lecture.

Prerequisites
none

T 7.221 Course: Seminar New Components and Systems of Power Electronics [T-ETIT-100713]

Responsible: Prof. Dr.-Ing. Marc Hiller
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100396 - Seminar New Components and Systems of Power Electronics

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4	Grade to a third	Each term	2

Events					
WT 24/25	2306317	New Components and Systems of Power Electronics	3 SWS	Seminar / 🗣	Hiller

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.222 Course: Seminar Novel Concepts for Solar Energy Harvesting [T-ETIT-108344]

Responsible: Prof. Dr. Bryce Sydney Richards
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-103447 - Seminar Novel Concepts for Solar Energy Harvesting

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	3	Grade to a third	Each summer term	2

Competence Certificate
The examination consists of a written journal article and an oral presentation of the student’s work, both given in English. The overall impression is rated.

Prerequisites
none

T 7.223 Course: Seminar on Applied Superconductivity [T-ETIT-111243]

Responsible: Prof. Dr. Tabea Arndt
Prof. Dr. Bernhard Holzapfel
Prof. Dr. Sebastian Kempf
Prof. Dr.-Ing. Mathias Noe

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: M-ETIT-105615 - Seminar on Applied Superconductivity

Type	Credits	Grading scale	Recurrence	Expansion	Version
Examination of another type	3	Grade to a third	Each summer term	1 terms	2

Events					
WT 24/25	2310551	Seminar on Applied Superconductivity	2 SWS	Seminar / ✕	Arndt, Holzapfel, Kempf, Noe
ST 2025	2310542	Seminar on Applied Superconductivity	2 SWS	Seminar / 🗣	Kempf, Arndt, Holzapfel, Noe

Legend: 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate

Elaboration of a scientific topic and presentation of a talk on the topic within the seminar of about 30min.

T 7.224 Course: Seminar Radar and Communication Systems [T-ETIT-100736]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100428 - Seminar Radar and Communication Systems

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4	Grade to a third	Each term	1

Competence Certificate
The performance evaluation takes place by means of an overall examination of the selected courses, the sum total of which fulfills the minimum requirement of course credits.

The examination takes place in the form of submission of a written report (paper) along with an oral presentation of the individual work. Both are taken into account, while grading the examination performance. The overall impression will be evaluated.

Prerequisites
none

Recommendation
Knowledge of fundamentals of radio frequency engineering are helpful.

T 7.225 Course: Seminar Selected Topics in Communications [T-ETIT-100962]

Responsible: Dr.-Ing. Holger Jäkel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100441 - Seminar Selected Topics in Communication

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4	Grade to a third	Each term	1

Events					
WT 24/25	2310512	Seminar Selected Topics in Communications	3 SWS	Seminar /	Jäkel

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Prerequisites
none

T 7.226 Course: Seminar Sensors [T-ETIT-100707]

Responsible: Dr. Wolfgang Menesklou
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100380 - Seminar Sensors

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	3	Grade to a third	Each term	1

Events					
WT 24/25	2304233	Seminar Sensor Technology	2 SWS	Seminar / 🗣	Menesklou

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.227 Course: Sensors [T-ETIT-101911]

Responsible: Dr. Wolfgang Menesklou
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100378 - Sensors

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	2

T 7.228 Course: Signal Processing in Communications [T-ETIT-100747]

Responsible: Dr.-Ing. Holger Jäkel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100443 - Signal Processing in Communications

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each summer term	2

Prerequisites
none

T 7.229 Course: Signal Processing Lab [T-ETIT-113369]

Responsible: Prof. Dr.-Ing. Sander Wahls
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106633 - Signal Processing Lab

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each summer term	1

Events					
ST 2025	2302134	Signal Processing Lab	4 SWS	Practical course /	Wahls, van Wijk

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
Success is assessed in the form of a written examination lasting 120 minutes.

Prerequisites
none

Recommendation
Knowledge of the contents of the modules "Signals and Systems", "Measurement Technology" and "Methods of Signal Processing" is strongly recommended.

Annotation
A prerequisite for admission to the examination is the submission of protocols of all experiments. The quality of the protocols will be assessed; they must be acceptable for admission to the examination.

Attendance is compulsory during all practical sessions, including the introductory session. Admission to the examination will not be granted for even one unexcused absence.

T 7.230 Course: Signal Processing Methods [T-ETIT-113837]

Responsible: Prof. Dr.-Ing. Sander Wahls
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106899 - Signal Processing Methods

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 24/25	2302113	Signal Processing Methods	2 SWS	Lecture /	Wahls
WT 24/25	2302115	Tutorial to 2302113 Signal Processing Methods	2 SWS	Practice /	Wahls, Al-Hammadi

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
Written exam, approx. 120 minutes.
The module grade is the grade of the written exam.

Prerequisites
none

Recommendation
Familiarity with signals and systems (in particular, Fourier transforms) and probability theory at the Bachelor level is assumed.

T 7.231 Course: Signal Processing with Nonlinear Fourier Transforms and Koopman Operators [T-ETIT-113428]

Responsible: Prof. Dr.-Ing. Sander Wahls
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106675 - Signal Processing with Nonlinear Fourier Transforms and Koopman Operators

Type	Credits	Grading scale	Version
Written examination	6	Grade to a third	1

Events					
ST 2025	2302135	Signal Processing with Nonlinear Fourier Transforms and Koopman Operators	2 SWS	Lecture / 🗣	Wahls
ST 2025	2302136	Practice to 2302135 Signal Processing with Nonlinear Fourier Transforms and Koopman Operators	2 SWS	Practice / 🗣	Wahls, Liang

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The examination in this module consists of programming assessments and a graded written examination of 120 minutes.

The programming assignments are either pass or fail. They must be passed during the lecture period for admission to the written examination.

The module grade is the grade of the written exam.

Prerequisites
none

T 7.232 Course: SIL Entrepreneurship Project [T-WIWI-110166]

Responsible: Prof. Dr. Orestis Terzidis
Organisation: KIT Department of Economics and Management
Part of: M-ETIT-105073 - Student Innovation Lab

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2545082	SIL Entrepreneurship Project	4 SWS	Seminar	Terzidis

Competence Certificate
Alternative exam assessment (§4(2), 3 SPO). The final grade is a result from both, the grade of the term paper and its presentation, as well as active participation during the seminar. In addition, smaller, ungraded tasks are provided in the course to monitor progress.

Prerequisites
None

Recommendation
None

T 7.233 Course: Single-Crystal Growth – Crystal Growth Methods and Applications of Crystals for Electronic and Optical Components [T-ETIT-113293]

Responsible: Prof. Dr. Marc Eichhorn

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: M-ETIT-106597 - Single-Crystal Growth – Crystal Growth Methods and Applications of Crystals for Electronic and Optical Components

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Each winter term	1 terms	1

Events					
WT 24/25	2303182	Single-Crystal Growth – Crystal Growth Methods and Applications of Crystals for Electronic and Optical Components	2 SWS	Lecture /	Ackermann

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

T 7.234 Course: Single-Photon Detectors [T-ETIT-108390]

Responsible: Dr. Konstantin Ilin
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-101971 - Single-Photon Detectors

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2312680	Single-Photon Detectors	2 SWS	Lecture / 🗣	Ilin
WT 24/25	2312694	Tutorial for 2312680 Single-Photon Detectors	1 SWS	Practice / 🗣	Ilin

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.235 Course: Software Engineering [T-ETIT-108347]

Responsible: Dr. Clemens Reichmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100450 - Software Engineering

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	3

Prerequisites
none

T 7.236 Course: Solar Energy [T-ETIT-100774]

Responsible: Prof. Dr. Bryce Sydney Richards
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100524 - Solar Energy

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 24/25	2313745	Solar Energy	3 SWS	Lecture / 🗣	Richards, Paetzold
WT 24/25	2313750	Tutorial 2313745 Solar Energy	1 SWS	Practice / 🗣	Richards, Paetzold

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
Students not allowed to take either of the following modules in addition to this one: „Solarenergie“ (M-ETIT-100476) and „Photovoltaik“ (M-ETIT-100513).

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-ETIT-101939 - Photovoltaics must not have been started.

T 7.237 Course: Solar Thermal Energy Systems [T-MACH-106493]

Responsible: apl. Prof. Dr. Ron Dagan
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-101924 - Solar Thermal Energy Systems

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	4

Events					
WT 24/25	2189400	Solar Thermal Energy Systems	2 SWS	Lecture / 🗣	Dagan

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
oral exam of about 30 minutes

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-MACH-105225 - Thermal Solar Energy must not have been started.

Recommendation
Literature

1. "Solar Engineering of Thermal Processes", 4th Edition, J. Duffie &W. Beckman. Published by Wiley & Sons
2. “Heat Transfer”, 10th Edition, J. P. Holman Mc. Graw Hill publisher
3. “Fundamentals of classical Thermodynamics”, G. Van Wylen & R. E. Sonntag. Published by Wiley &Sons

T 7.238 Course: Source Coding Techniques [T-ETIT-110673]

Responsible: Prof. Dr.-Ing. Laurent Schmalen
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105273 - Source Coding Techniques

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Each winter term	1 terms	2

Competence Certificate
The assessment will be in the form of an oral exam aprox. 20 minutes. The module grade is the grade of the oral exam.

Prerequisites
Knowledge of basic engineering mathematics including integral transformations and probability theory as well as basic knowledge of communications engineering.

Recommendation
Previous visit to the lecture "Telecommunications I", "Probability Theory" and "Signals and Systems" is recommended. Knowledge from the lectures "Applied Information Theory" is helpful, but not necessary.

T 7.239 Course: Space-Born Microwave Radiometry-Advanced Methods and Applications [T-ETIT-100810]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100545 - Space-Born Microwave Radiometry - Advanced Methods and Applications

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Events					
ST 2025	2308448	Space-borne Microwave Radiometry - Advanced Methods and Applications	2 SWS	Lecture / 🗣	Jirousek

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.240 Course: Spaceborne Radar Remote Sensing - Exam [T-ETIT-112857]

Responsible: Prof. Dr.-Ing. Alberto Moreira
Dr. Pau Prats

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: M-ETIT-103042 - Spaceborne Radar Remote Sensing

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each summer term	1

Competence Certificate
The assessment takes place in the form of a written examination lasting 120 min.

Prerequisites
"T-ETIT-106056 - Spaceborne Radar Remote Sensing" is not allowed to be started or to be completed.

Recommendation
Signal processing and radar fundamentals.

Annotation
Further information can be found at the internet page of the IHE (https://s.kit.edu/ihe-srrs).

T 7.241 Course: Spaceborne Radar Remote Sensing - Workshop [T-ETIT-112858]

Responsible: Prof. Dr.-Ing. Marwan Younis
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-103042 - Spaceborne Radar Remote Sensing

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	2	Grade to a third	Each summer term	1

Competence Certificate
The assessment takes place in the form of reports (other types of examination). Those reports have to be submitted as part of the SAR computer workshop (approx. a total of five workshops). Details will be given during the lecture.

Prerequisites
"T-ETIT-106056 - Spaceborne Radar Remote Sensing" is not allowed to be started or to be completed.

Recommendation
Signal processing and radar fundamentals.

Annotation
Further information can be found at the internet page of the IHE (https://s.kit.edu/ihe-srrs).

T 7.242 Course: Stochastic Information Processing [T-INFO-101366]

Responsible: Prof. Dr.-Ing. Uwe Hanebeck
Organisation: KIT Department of Informatics
Part of: M-INFO-100829 - Stochastic Information Processing

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	1

Events					
WT 24/25	2424113	Stochastic Information Processing	3 SWS	Lecture / 🗣	Hanebeck, Frisch

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 7.243 Course: Superconducting Magnet Technology [T-ETIT-113440]

Responsible: Prof. Dr. Tabea Arndt
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106684 - Superconducting Magnet Technology

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each summer term	1

Competence Certificate
The examination takes place in form of an oral exam (abt. 30 minutes).

Two timeslots (weeks) for examination dates will be announced (usually near end of lecture period & end of semester).

The module grade is the grade of the oral exam.

Prerequisites
none

7.244 Course: Superconducting Materials [T-ETIT-111096]

Responsible: Prof. Dr. Bernhard Holzapfel
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105521 - Superconducting Materials

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each term	2

Events					
WT 24/25	2312717	Superconducting Materials Part I	2 SWS	Lecture / 🗣	Holzapfel, Hänisch

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment of success takes place in the form of an oral examination lasting 40 minutes.

The oral examination includes the contents of Superconducting Materials Part I (offered every winter term) and Superconducting Materials Part II (offered every summer term).

Prerequisites
none

Recommendation
Knowledge of the basic course “Superconductivity for Engineers” is required

T 7.245 Course: Superconducting Nanowire Detectors [T-ETIT-111236]

Responsible: Prof. Dr. Sebastian Kempf
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105609 - Superconducting Nanowire Detectors

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	4	Grade to a third	Each summer term	1 terms	2

Competence Certificate
Oral Exam (20 min.)

T 7.246 Course: Superconducting Power Systems [T-ETIT-113439]

Responsible: Prof. Dr.-Ing. Mathias Noe
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106683 - Superconducting Power Systems

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2314011	Superconducting Power Systems	3 SWS	Lecture / Practice (/	Noe

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
The examination takes place in form of an oral exam (abt. 45 minutes).

The module grade is the grade of the oral exam.

Prerequisites
none

T 7.247 Course: Superconductivity for Engineers [T-ETIT-111239]

Responsible: Prof. Dr. Bernhard Holzapfel
Prof. Dr. Sebastian Kempf

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: M-ETIT-105611 - Superconductivity for Engineers

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	5	Grade to a third	Each winter term	1 terms	3

Events					
WT 24/25	2312708	Superconductivity for Engineers	2 SWS	Lecture / 🗣	Kempf, Holzapfel
WT 24/25	2312709	Exercise for 2312708 Superconductivity for Engineers	1 SWS	Practice / 🗣	Ilin, Hänisch

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment of success takes place in the form of a written examination lasting 120min. The grade corresponds to the result of the written examination.

Prerequisites
none

T 7.248 Course: System Integration and Communication Structures in Industry 4.0 and IoT [T-ETIT-112212]

Responsible: Prof. Dr.-Ing. Jürgen Becker
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106026 - System Integration and Communication Structures in Industry 4.0 and IoT

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Each winter term	1 terms	1

Events					
WT 24/25	2311614	System Integration and Communication Structures in Industry 4.0 and IoT	2 SWS	Lecture / 🗣	Babel

Legend: 🖥 Online, ✲ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.249 Course: System-on-Chip Laboratory [T-ETIT-100798]

Responsible: Prof. Dr.-Ing. Jürgen Becker
Prof. Dr. Ivan Peric
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100451 - System-on-Chip Laboratory

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each winter term	1

Events					
WT 24/25	2311612	Laboratory System-on-Chip	4 SWS	Practical course / 🗣	Becker, Peric

Legend: 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Prerequisites
none

T 7.250 Course: Systems and Software Engineering [T-ETIT-100675]

Responsible: Prof. Dr.-Ing. Eric Sax
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100537 - Systems and Software Engineering

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	2

Events					
WT 24/25	2311605	Systems and Software Engineering	2 SWS	Lecture /	Sax
WT 24/25	2311607	Tutoral for 2311605 Systems and Software Engineering	1 SWS	Practice /	Nägele

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
Written exam, approximately 90 minutes.

Students are given the opportunity to earn a grade bonus through separate task assignments. If the grade of the written exam is between 4.0 and 1.3, the bonus improves the grade by a maximum of one grade level (0.3 or 0.4). The exact criteria for awarding a bonus will be announced at the beginning of the lecture. Bonus points do not expire and remain valid for exams taken at a later date:

The grade is determined by the written exam and the bonus points.

Prerequisites
none

T 7.251 Course: Systems Engineering for Automotive Electronics [T-ETIT-100677]

Responsible: Hon.-Prof. Dr. Jürgen Bortolazzi
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100462 - Systems Engineering for Automotive Electronics

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each summer term	1

Prerequisites
none

T 7.252 Course: Team Project: Sensors and Electronics [T-ETIT-111007]

Responsible: Prof. Dr.-Ing. Ahmet Cagri Ulusoy
Prof. Dr.-Ing. Thomas Zwick

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: M-ETIT-105465 - Team Project: Sensors and Electronics

Type	Credits	Grading scale	Recurrence	Expansion	Version
Completed coursework	3	pass/fail	Each term	1 terms	2

Events					
WT 24/25	2308425	Team Project: Sensors and Electronics	2 SWS	Project (P /	Ulusoy, Zwick

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
see module description

T 7.253 Course: Technical Acoustic [T-ETIT-104579]

Responsible: Dr. Nicole Ruiter
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-101835 - Technical Acoustic

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2305296	Technical Acoustic	2 SWS	Lecture /	Ruiter

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Competence Certificate
Success control is carried out as part of an overall oral examination (approx. 20 minutes) of the selected courses, with which the minimum requirement for CP is met.

Prerequisites
none

T 7.254 Course: Technical Optics [T-ETIT-100804]

Responsible: Prof. Dr. Cornelius Neumann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100538 - Technical Optics

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	1

Events					
WT 24/25	2313720	Technical Optics	2 SWS	Lecture / 🗣	Neumann
WT 24/25	2313722	Technical Optics (Tutorial to 2313720)	1 SWS	Practice / 🗣	Neumann

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.255 Course: Telematics [T-INFO-101338]

Responsible: Prof. Dr. Martina Zitterbart
Organisation: KIT Department of Informatics
Part of: M-INFO-100801 - Telematics

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 24/25	2424128	Telematics	4 SWS	Lecture / 🗣	Zitterbart, Kopmann, Seehofer, Mahrt, Helmig

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 90 minutes.

Depending on the number of participants, it will be announced six weeks before the examination (Section 6 (3) SPO) whether the assessment will take the form of an oral examination of approx.

- in the form of an oral examination of approx. 30 minutes in accordance with § 4 Para. 2 No. 2 SPO or

- in the form of a written examination in accordance with § 4 Para. 2 No. 1 SPO

takes place.

Prerequisites
None

Recommendation

- Contents of the lecture ***Introduction to computer networks***or comparable lectures are a prerequisite.
- Attendance of the module-accompanying ***basic practical course Protocol Engineering*** is recommended.

T 7.256 Course: Test of Embedded Systems in Industrial Contexts [T-ETIT-100811]

Responsible: Prof. Dr.-Ing. Eric Sax
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100546 - Test of Embedded Systems in Industrial Contexts

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2311648	Test of Embedded Systems in Industrial Contexts	2 SWS	/ 🗣	Schmerler
WT 24/25	2311649	Test of Embedded Systems in Industrial Contexts (Tutorial to 2311649)	1 SWS	Practice / 🗣	Ransiek

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 7.257 Course: The Energy Transition of the Electrical Transmission grid [T-ETIT-111248]

Responsible: Prof. Dr.-Ing. Thomas Leibfried
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105618 - The Energy Transition of the Electrical Transmission Grid

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Each summer term	1 terms	1

Prerequisites
none

T 7.258 Course: Theoretical Foundations of Cryptography [T-INFO-111199]

Responsible: Prof. Dr. Jörn Müller-Quade
Organisation: KIT Department of Informatics
Part of: M-INFO-105584 - Theoretical Foundations of Cryptography

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 24/25	2400237	Theoretische Grundlagen der Kryptographie	4 SWS	Lecture / 🗣	Müller-Quade, Berger

Legend: 🖥 Online, ⯐ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 7.259 Course: Thermal Solar Energy [T-MACH-105225]

Responsible: apl. Prof. Dr. Ron Dagan
Organisation: KIT Department of Mechanical Engineering

Part of: M-MACH-102388 - Thermal Solar Energy

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	2

Events					
WT 24/25	2189400	Solar Thermal Energy Systems	2 SWS	Lecture / 🗣	Dagan

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Oral examination of about 30 minutes

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-MACH-106493 - Solar Thermal Energy Systems must not have been started.

T 7.260 Course: Ultrasound Imaging [T-ETIT-100822]

Responsible: Dr. Nicole Ruiter
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100560 - Ultrasound Imaging

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Prerequisites
none

T 7.261 Course: Universal Composability in Cryptography [T-INFO-111584]

Responsible: Prof. Dr. Jörn Müller-Quade
Organisation: KIT Department of Informatics
Part of: M-INFO-105783 - Universal Composability in Cryptography

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 24/25	2400022	Universal Composability in Cryptography	2 SWS	Lecture / 🗣	Müller-Quade, Mechler

Legend: 🖥 Online, ❖ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 7.262 Course: Vacuum Technology [T-CIWVT-109154]

Responsible: Dr.-Ing. Thomas Giegerich

Organisation: KIT Department of Chemical and Process Engineering
KIT Department of Electrical Engineering and Information Technology

Part of: M-CIWVT-104478 - Vacuum Technology

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	1

Events					
WT 24/25	2250810	Vacuum Technology	2 SWS	Lecture / 🗣	Giegerich, Tantos
WT 24/25	2250811	Vacuum Technology - Exercises	1 SWS	Practice / 🗣	Tantos, Giegerich

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The examination is an oral examination with a duration of about 20 minutes (section 4 subsection 2 number 2 SPO).

Prerequisites
None

T 7.263 Course: Verified Numerical Methods [T-ETIT-109184]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-104493 - Verified Numerical Methods

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 24/25	2303001	Verified numerical methods	2 SWS	Lecture / 🗘	Nagato-Plum
WT 24/25	2303002	Verified Numerical Methods (Tutorial to 2303001)	1 SWS	Practice / 🗣	Nagato-Plum

Legend: 🖥 Online, 🗘 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 7.264 Course: Visual Perception in the Automobile [T-ETIT-100777]

Responsible: Prof. Dr. Cornelius Neumann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100497 - Visual Perception in the Automobile

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Prerequisites
none

7.265 Course: Water – Energy – Environment Nexus in a Circular Economy: Research Proposal Preparation [T-CIWVT-113433]

Organisation: KIT Department of Chemical and Process Engineering

Part of: M-CIWVT-106680 - Water – Energy – Environment Nexus in a Circular Economy: Research Proposal Preparation

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	5	Grade to a third	Each summer term	1

Events					
ST 2025	2233130	Circular Economy Water Energy Environment: Research Proposal Preparation	4 SWS	Lecture / 🗣	Schäfer

Legend: 🖥 Online, ❂ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The Learning control is an examination of another type:
Research proposal of 10 pages and an oral presentation of 10 minutes (individual work). The grade will be a composite of the proposal (submission in week 13 before class) and oral & poster presentation (all day workshop with researcher participation).

Prerequisites
None

T 7.266 Course: Wearable Robotic Technologies [T-INFO-106557]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Prof. Dr.-Ing. Michael Beigl

Organisation: KIT Department of Informatics

Part of: M-INFO-103294 - Wearable Robotic Technologies

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each summer term	4

Competence Certificate
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 60 minutes.

Prerequisites
Attending the lecture Mechano-Informatics and Robotics is recommended.

Recommendation
Attending the lecture Mechano-Informatics and Robotics is recommended.

T 7.267 Course: Workshop Finite Element Method in Electromagnetics [T-ETIT-100818]

Responsible: Prof. Dr. Martin Doppelbauer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100555 - Workshop Finite Element Method in Electromagnetics

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	3	Grade to a third	Each summer term	1

Prerequisites
none