FRANKFURT UNIVERSITY OF APPLIED SCIENCES

Module handbook

for a consecutive, study program in

Information Technology (dreisemestrig)

M.Eng.

Department 2: Computer Science and Engineering

Table of Contents

1. Qualification Objectives

On successful completion of the Master-Program “Information Technology (dreisemestrig)” the students have acquired a post graduate qualification to be technical specialists and technical managers for positions in the information technology industry.

The students have gathered profound knowledge in advanced mathematics and information and communication technology. They have improved and enhanced their knowledge in advanced theoretical methods of engineering and specialized their applied engineering knowledge, which serve as a base for further innovative approaches.

Graduates are competent and qualified to think in a multi- and interdisciplinary way when applying laws and principles of information technology in order to solve challenging and complex technical problems, particularly in reference to the development of new technologies, products, and services. They possess skills and experiences in digital communication systems, optical and microwave systems or in intelligent systems, intelligent sensors and pattern recognition.

Specific courses like the "Project Course" enable the Students to be qualified in the design of projects, processes, the mastering of change management and the creation of new strategic approaches. They will be able to contribute to the enhancement of technical knowledge and lead and manage international teams and projects. They are able to master complex and unpredictable problems with innovative solutions. They are able to apply modern project management methods and to respect cultural and social aspects of project work in international R&D teams.

By experiencing a variety of situations in laboratories during specific project work, the students acquire specific skills in innovative engineering methods and strategies and will be reflective practitioners who assess the ethical and societal dimensions of their work.

The students identify and reflect the professional requirements and are prepared for lifelong learning. They are able to use presentation skills, apply self and project management, gather information that is suited for academic discussion, and describe requirements, problems and results in English language. They dispose of key competences in technical English, in social interaction (team work, project work) and in professional presentation and communication.

The prospective engineers are qualified for positions in academia, public administration and industry e.g. technical specialists or technical managers or for pursuing a PhD. They have acquired and applied different methods that allow them to work in research and development of integrated product and service concepts in the area of information technology. Career opportunities include research and development of technical systems and the management of such projects. They qualified as technical specialists and technical managers in the information technology industry.

2. Module Overview of Degree Program

Information Technology (dreisemestrig) (M.Eng.)							FRANKFURT UNIVERSITY OF APPLIED SCIENCES
							ECTS Punkte (CP)
Semester 3	13 **Master Thesis and Colloquium** 30 cp						30
Semester 2	7 **Machine Learning** 5 cp	8 **Mobile Computing** 5 cp	9 **Field Theory for Optical and Microwave Communication Systems** 5 cp	10 **Autonomous Intelligent Systems** 5 cp	11 **Optional Technical Subject** 5 cp	12 **Project** 5 cp	30
Semester 1	1 **Vector Analysis** 5 cp	2 **Stochastic Signals and Systems** 5 cp	3 **Digital Baseband Transmission and Modulation Methods** 5 cp	4 **Cloud Computing** 5 cp	5 **Digital Switching and Routing** 5 cp	6 **Computational Intelligence** 5 cp	30

Information Technology (dreisemestrig) (M.Eng.)

3. ECTS/Workload overview

Nr.	Module Title	ECTS (CP)	Duration [Sem.]	Examination Type	Language	Weight
Semester 1						
1	Vector Analysis	5	1	Written examination	English	1
2	Stochastic Signals and Systems	5	1	Written examination	English	1
3	Digital Baseband Transmission and Modulation Methods	5	1	Written examination	English	1
4	Cloud Computing	5	1	Project, written report and presentation	English	1
5	Digital Switching and Routing	5	1	Written examination	English	1
6	Computational Intelligence	5	1	Written seminar paper, presentation	English	1
Semester 2						
7	Machine Learning	5	1	Project, written report and presentation	English	1
8	Mobile Computing	5	1	Project, documentation and presentation	English	1
9	Field Theory for Optical and Microwave Communication Systems	5	1	Written examination	English	1
10	Autonomous Intelligent Systems	5	1	Project, written report	English	1
11	Optional Technical Subject*	5	1	Project, written report and presentation	English	1
12	Project	5	1	Project, presentation	English	1
Semester 3						
13	Master Thesis and Colloquium	30	1	Written report, presentation and colloquium	English	6

*Zwei unterschiedliche Wahlpflichtmodule werden aus einem vom Fachbereichsrat beschlossenen Pool ausgewählt. Zu diesem Pool gehören u.a. die nachfolgend aufgeführten Module:
11.1. Engineering of Microwave Systems
11.2. Engineering of Optical Systems

4. Module Descriptions

Module 1

Module title	Vector Analysis
Module number	1
Module code	
Study program	Information Technology (dreisemestrig)
Module usability	Information Technology (viersemestrig)
Module duration	One semester
Recommended semester	1st semester
Module type	Compulsory module
ECTS (CP) / Workload (h)	5 CP / 150 h
Recommended previous knowledge	The module is based on knowledge or skills in Analysis and Linear Algebra acquired in an appropriate Bachelor course for this Master course.
Module prerequisites	none
Module examination requirements	none
Module examination	Written examination (90 minutes)
Learning outcomes and skills	Upon completion of the module the students are able to: • summarize the basic ideas of Vector Spaces. • explain the concepts of Linear Independency, Coordinates and Bases of Vector Spaces. • use the scalar product and dot product in Euclidian Spaces to solve geometric problems in 3 dimensional spaces. • apply vector equations of lines and planes to describe geometric problems. • recognize vector functions in the subject-specific environment of the program and apply the methods of integral and differential calculus to them. In particular, describe movements, speeds and accelerations of objects in space using parametric curves and determine their properties such as arc length and curvature. name and explain the concepts of scalar fields and vector fields • describe the extensions of the Differential Calculus to scalar fields. • compute extrema and extrema with constraints of scalar fields. • name the concepts of multiple integrals. • apply Iterated Integrals and integration by substitution to calculate volumes. • recognize the different types of integrals volume (integral, line integral and surface and the integral theorems) relating to these types of integrals. • transfer the integral theorems to applications and to the context of electrical engineering. transfer the mathematical knowledge about scalar and vector fields to describe and

	solve engineering problems.
Module contents	Vector analysis
Module teaching methods	Lectures combined with exercises in Vector Analysis
Module language	English
Module availability	Winter semester
Module coordination	Prof. Dr. Egbert Falkenberg
Comments	

Unit 1.1: Lectures combined with exercises in Vector Analysis

Unit title	Lectures combined with exercises in Vector Analysis
Code	1
Module title	Vector Analysis

Unit contents	• Vector Calculus
	  ○ Definition and Examples of Vector Spaces and Subspaces
	  ○ Linear Independence, Coordinates and Bases
	  ○ Euclidean Spaces
	• Vector Functions
	  ○ Definition, Limits, Continuity
	  ○ Derivatives and Integrals
	  ○ Arc Length and Curvature
	  ○ Basic properties of Curves
	• Scalar Fields: Function of Several Variables
	  ○ Definition, Examples and Visualizations
	  ○ Limits and Continuity
	  ○ Partial Derivatives
	  ○ Tangent Plane
	  ○ Chain Rule
	  ○ Implicit Functions
	  ○ Extremas
	  ○ Extrema with Constraints
	• Vector Fields
	  ○ Definition and Examples
	  ○ Gradient Fields
	  ○ Line Integrals
	  ○ Independence of the Path
	  ○ Existence of Potentials
	  ○ Conservation of Energy
	  ○ Green's Theorem
	  ○ Surface Integrals
	  ○ Stokes Theorem
	  ○ Divergence Theorem

Teaching methods	Lectures combined with exercises
Semester periods (hours) per week	4
Workload (h)	150 h
Class hours	60 h, including 15 h exercises
Total time of examination incl.	10 h

preparation (h)	
Total time of individual study (h)	80 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Falkenberg
Recommended reading	• H. Anton, Calculus A new horizon, 9th Edition, John Wiley and Sons, New York, 2009 • H. Anton, Elementary Linear Algebra, 10th edition, John Wiley and Sons, New York, 2010 • J. Stewart, Calculus Early Transcendentals, Sixth Edition, Thomson Brooks/Cole, Canada, 2008
Assessment type and form of	
Assessment grading	
Comments	

Module 2

Module title	Stochastic Signals and System
Module number	2
Module code	
Study program	Information Technology (dreisemestrig)
Module usability	Information Technology (viersemestrig)
Module duration	One semester
Recommended semester	1st semester
Module type	Compulsory module
ECTS (CP) / Workload (h)	5 CP / 150 h
Recommended previous knowledge	Probability calculus Matlab
Module prerequisites	None
Module examination requirements	Exercises (processing time: 30 hours)
Module examination	Written examination (120 minutes)
Learning outcomes and skills	Upon completion of the module the students are able to: • analyze stochastic processes in information and communication systems, judge estimation methods for parameter estimation on stochastic signals, summarize the theory of non-recursive and recursive optimum systems, • choose appropriate optimum systems for information and communication, • create recursive estimators and predictors, describe colored noise as well as correlated measurement noise, create extended Kalman filters.
Module contents	Stochastic Signals and Systems Lecture Stochastic Signals and Systems Exercises
Module teaching methods	Lectures, exercises
Module language	English
Module availability	Summer semester
Module coordination	Prof. Dr. Andreas Pech
Comments	

Unit 2.1: Stochastic Signals and Systems Lecture

Unit title	Stochastic Signals and Systems Lecture

Code	
Module title	Stochastic Signals and Systems
Unit contents	Random processes: • Fundamentals of linear and nonlinear systems. • Fundamentals of estimation and prediction. • Maximum likelihood estimation and other estimation methods and their properties. Optimum systems: • Optimum non-recursive estimation. • Wiener-Hopf equation. • Optimum recursive estimation. • Kalman filter. • Colored noise, correlated measurement noise. • Nonlinear minimum variance estimation. • Extended Kalman filter.
Teaching methods	Lecture
Semester periods (hours) per week	3
Workload (h)	60 h
Class hours	45 h
Total time of examination incl. preparation (h)	The individual study (see below) includes the time of examination incl. preparation
Total time of individual study (h)	15 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Pech
Recommended reading	Ash, C.: The probability Tutoring Book, IEEE Press 1993. Cariolaro, G.: Unified Signal Theory, Springer 2011. Additional up-to-date reading information will be provided at the beginning of the lecture.
Assessment type and form of	
Assessment grading	
Comments	

Unit 2.2: Stochastic Signals and Systems Exercises

Unit title	Stochastic Signals and Systems Exercises

Code	
Module title	Stochastic Signals and Systems
Unit contents	Six exercises on Stochastic Signals and Systems
Teaching methods	Exercise
Semester periods (hours) per week	2
Workload (h)	90 h
Class hours	30 h
Total time of examination incl. preparation (h)	The individual study (see below) includes the time of examination incl. preparation
Total time of individual study (h)	60 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Pech
Recommended reading	Ash, C.: The probability Tutoring Book, IEEE Press 1993. Cariolaro, G.: Unified Signal Theory, Springer 2011. Additional up-to-date reading information will be provided at the beginning of the lecture.
Assessment type and form of	The students submit each exercise solution within one week after issue. Each submitted exercise will be assessed (“passed” or “failed”).
Assessment grading	4 or more passed exercises: “passed” Less than 4 passed exercises: “failed”
Comments	

Module 3

Module title	Digital Baseband Transmission and Modulation Methods
Module number	3
Module code	
Study program	Information Technology (dreisemestrig)
Module usability	Information Technology (viersemestrig)
Module duration	one semester
Recommended semester	1st semester
Module type	compulsory module
ECTS (CP) / Workload (h)	5 CP / 150 h
Recommended previous knowledge	Basics of Transmission / Communications Engineering, Basics of Higher Mathematics
Module prerequisites	None
Module examination requirements	None
Module examination	Written examination, 90 minutes
Learning outcomes and skills	Upon completion of the module the students are able to • explain the purpose for modulation either in baseband or in another frequency band. • choose an appropriate transmission method for a given use case. • design the system architecture and specify the hardware and the software structure of transmission nodes. • justify the choice of the modulation technique according to the transmission channel. • estimate the correctness of the received signals.
Module contents	Digital Baseband Transmission and Modulation Methods Lectures
Module teaching methods	Lectures combined with exercises
Module language	English
Module availability	Summer semester
Module coordination	Prof. Dr.-Ing. Kira Kastell
Comments	Parts of the lecture may contain online content

Unit 3.1: Digital Baseband Transmission and Modulation Methods Lectures

Unit title	Digital Baseband Transmission and Modulation Methods Lectures

Code	
Module title	Digital Baseband Transmission and Modulation Methods
Unit contents	Digital baseband transmission: • pulse shaping, • eye-diagram, • sampling, • Nyquist criteria, • special filters, • line coding. Modulation: • amplitude shift keying (ASK), • frequency shift keying (FSK), • phase shift keying (PSK), • continuous phase frequency shift keying (CPFSKK), • amplitude phase shift keying (APK), • continuous phase modulation (CPM), • prerequisites for demodulation basics of optical transmission, • probability considerations for the choice of modulation methods and demodulation
Teaching methods	Lectures combined with exercises
Semester periods (hours) per week	4
Workload (h)	150 h
Class hours	60 h
Total time of examination incl. preparation (h)	10 h
Total time of individual study (h)	80 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Kastell, Dankmeier
Recommended reading	Haykin, Simon; Moher, Michael: An Introduction to Digital and Analog Communications, Wiley 2006. Proakis, John G.; Salehi, Masoud: Digital Communications, McGraw-Hill Education 2007. Proakis, John G.; Salehi, Masoud: Fundamentals of Communication Systems, Pearson 2013. Lecture notes
Assessment type and form of	None
Assessment grading	None

Comments	None

Module 4

Module title	Cloud Computing
Module number	4
Module code	
Study program	Information Technology (dreisemestrig)
Module usability	Information Technology (viersemestrig)
Module duration	One semester
Recommended semester	1st semester
Module type	Compulsory module
ECTS (CP) / Workload (h)	5 CP / 150 h
Recommended previous knowledge	Programming
Module prerequisites	Module C: Software Engineering
Module examination requirements	None
Module examination	written project report (submission period 8 weeks, processing time 20 hours), with presentation (min. 5, max. 10 minutes)
Learning outcomes and skills	Upon completion of the module the students are able to: • analyze, design, validate and judge cloud computing systems, • facilitate situation-specific problem-solving solutions by acting in a constructive and conceptual manner, • assess their own project management capabilities, • use fact-based frameworks of actions and decisions autonomously and develop them further under guidance, • present results to a specialist audience and discuss conclusions, • assess the ethical and societal dimensions of applications.
Module contents	Cloud Computing Lecture Cloud Computing Project
Module teaching methods	List the forms of teaching of the individual units (PO/ER)
Module language	English
Module availability	Summer semester
Module coordination	Prof. Dr. Andreas Pech
Comments	

Unit 4.1: Cloud Computing Lecture

Unit title	Cloud Computing Lecture
Code	
Module title	Cloud Computing
Unit contents	• Introduction (Software as a Service etc.), • cloud storage, • computation (virtual machine, jobs, containers, serverless computation); • Actor programming model, • Architecture of cloud solutions.
Teaching methods	Lecture
Semester periods (hours) per week	2
Workload (h)	30 h
Class hours	30 h
Total time of examination incl. preparation (h)	0 h
Total time of individual study (h)	0 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Pech, Dobric
Recommended reading	Erl, T; Mahmood, Z..; Puttini, R..: Cloud Computing, Prentice Hall, 2014. Kavis, M.J.: Architecting the Cloud, Wiley 2014 .
Assessment type and form of	
Assessment grading	
Comments	

Unit 4.2: Cloud Computing Project

Unit title	Cloud Computing Project
Code	
Module title	Cloud Computing
Unit contents	Creation of a cloud computing application

Teaching methods	Project
Semester periods (hours) per week	2
Workload (h)	120 h
Class hours	30 h
Total time of examination incl. preparation (h)	The individual study (see below) includes the time of examination incl. preparation
Total time of individual study (h)	80 h
Total time of practical training (h)	10 h
Unit language	English
Lecturer	Pech, Dobric
Recommended reading	Erl, T; Mahmood, Z..; Puttini, R..: Cloud Computing, Prentice Hall, 2014. Kavis, M.J.: Architecting the Cloud, Wiley 2014.
Assessment type and form of	
Assessment grading	
Comments	

Module 5

Module title	Digital Switching and Routing
Module number	5
Module code	
Study program	Information Technology (dreisemestrig)
Module usability	Information Technology (viersemestrig)
Module duration	One semester
Recommended semester	1st semester
Module type	Compulsory module
ECTS (CP) / Workload (h)	5 CP / 150 h
Recommended previous knowledge	Recommended prerequisites: Modul A – Methods, Systems and Networks for Digital Communication
Module prerequisites	None
Module examination requirements	Laboratory attestations (processing time 20 hours)
Module examination	Written examination, 90 minutes
Learning outcomes and skills	Upon completion of the module the students are able to: • explain the development, planning and operation of switching and routing systems; • analyse, specify and develop protocols and network nodes for switching and routing • identify correlations in complex systems • analyse systems and their optimization potential • manage application-oriented projects in a largely self-directed manner. • integrate existing – Ethernet, IPv4, MPLS – and new knowledge – IPv6, SDN – and handle complexity in networks based on the mentioned technologies • apply switching and routing networks in a largely self-directed manner • assess the ethical and societal dimensions of massive networking
Module contents	Lectures in Digital Switching and Routing Digital Switching and Routing Laboratory
Module teaching methods	Lectures combined with exercises Lab experiments
Module language	English
Module availability	Summer semester

Module coordination	Trick
Comments	

Unit 5.1: Lectures in Digital Switching and Routing

Unit title	Lectures in Digital Switching and Routing
Code	
Module title	Digital Switching and Routing
Unit contents	Ethernet switching: bridge, switch, backward learning, spanning tree protocol IP-Routing: IP network structure, routing, routing strategies, routing protocols QoS: overprovisioning, traffic engineering, IntServ, DiffServ IPv6: IPv6 versus IPv4, IPv6 header, IPv6 addresses, ICMPv6, NDP, DHCPv6, IPv4-IPv6 migration, different migration mechanisms MPLS (Multiprotocol Label Switching): architecture, functionality, protocols SDN (Software Defined Networking): architecture, functionality, protocols
Teaching methods	Lecture / Exercises
Semester periods (hours) per week	3
Workload (h)	75 h
Class hours	45 h
Total time of examination incl. preparation (h)	15 h
Total time of individual study (h)	15 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Trick
Recommended reading	Trick, Ulrich; Weber, Frank: SIP und Telekommunikationsnetze – Next Generation Networks und Multimedia over IP – konkret. De Gruyter Oldenbourg, 2015 Stallings, William: Data and Computer Communications. Pearson, 2010 Tanenbaum, Andrew S.; Wetherall, David: Computer Networks. Pearson, 2010 Monge, Antonio; Szarkowicz, Krzysztof: MPLS in the SDN Era – Interoperable Scenarios to Make Networks Scale to New Services. O´Reilly, 2016

	Göransson, Paul; Black, Chuck: Software Defined Networks – A Comprehensive Approach. Morgan Kaufmann, 2016 Additional up-to-date reading information will be announced at the beginning of the lecture.
Assessment type and form of	
Assessment grading	
Comments	

Unit 5.2: Digital Switching and Routing Laboratory

Unit title	Digital Switching and Routing Laboratory
Code	
Module title	Digital Switching and Routing
Unit contents	Experiment 1: SIP based communication infrastructure Experiment 2: IPv4 and IPv6 Experiment 3: Routing
Teaching methods	Lab Experiments
Semester periods (hours) per week	3
Workload (h)	75 h
Class hours	15 h
Total time of examination incl. preparation (h)	0 h
Total time of individual study (h)	30 h
Total time of practical training (h)	30 h
Unit language	English
Lecturer	Trick
Recommended reading	Trick, Ulrich; Weber, Frank: SIP und Telekommunikationsnetze – Next Generation Networks und Multimedia over IP – konkret. De Gruyter Oldenbourg, 2015 Stallings, William: Data and Computer Communications. Pearson, 2010 Tanenbaum, Andrew S.; Wetherall, David: Computer Networks. Pearson, 2010 Monge, Antonio; Szarkowicz, Krzysztof: MPLS in the SDN Era – Interoperable Scenarios to Make Networks Scale to New Services. O´Reilly, 2016 Göransson, Paul; Black, Chuck: Software Defined Networks – A

	Comprehensive Approach. Morgan Kaufmann, 2016 Worksheets. Additional up-to-date reading information will be announced at the beginning of the lecture.
Assessment type and form of	Lab certificate (processing time 20 hours)
Assessment grading	Passed/failed
Comments	

Module 6

Module title	Computational Intelligence
Module number	6
Module code	
Study program	Information Technology (dreisemestrig)
Module usability	Mechatronik und Robotik (Master), Information Technology (viersemestrig)
Module duration	One semester
Recommended semester	1st semester
Module type	Compulsory module
ECTS (CP) / Workload (h)	5 CP / 150 h
Recommended previous knowledge	Differential calculus Discrete-time systems Programming Module 4: Image Processing and Identification of Dynamic Systems
Module prerequisites	None
Module examination requirements	None
Module examination	Written seminar paper (submission period 6 weeks, processing time 20 hours). Presentation and discussion (20 minutes).
Learning outcomes and skills	Upon completion of the module the students are able to: • describe the theory of computational intelligence, • analyze real-world problems to develop strategies and algorithms for a problem solution and specify the respective hardware and software structure, • communicate their conclusions, the underlying assumptions and their reasoning to specialists and non-specialists both clearly and unambiguously on the basis of the state of research and application, • assess sociological aspects of intelligent algorithms, • analyze and reflect on his / her own communication style.
Module contents	Computational Intelligence Seminar
Module teaching methods	Presentation and supervised discussion
Module language	English
Module availability	Summer semester
Module coordination	Prof. Dr. Andreas Pech
Comments	

Unit 6.1: Computational Intelligence Seminar

Unit title	Computational Intelligence Seminar
Code	
Module title	Computational Intelligence
Unit contents	• Computational intelligence and knowledge • Uncertain knowledge • Machine Learning • Artificial neural networks • Convolutional neural networks • Deep learning • Additional topics, e.g. Fuzzy systems, reasoning system, classification, quantum computing, swarm intelligence, pattern recognition systems, learning strategies and algorithms, applications.
Teaching methods	Seminar
Semester periods (hours) per week	4 h
Workload (h)	150 h
Class hours	60 h
Total time of examination incl. preparation (h)	The individual study (see below) includes the time of examination incl. preparation
Total time of individual study (h)	90 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Pech
Recommended reading	Kruse, R. et al.: Computational Intelligence, Springer 2016. Goodfellow, I.; Bengio, Y.; Courville, A.: Deep Learning, MIT Press 2016.
Assessment type and form of	
Assessment grading	
Comments	

Module 7

Module title	Machine Learning
Module number	7
Module code	
Study program	Information Technology (dreisemestrig)
Module usability	Information Technology (viersemestrig)
Module duration	One semester
Recommended semester	2nd semester
Module type	Compulsory module
ECTS (CP) / Workload (h)	5 CP / 150 h
Recommended previous knowledge	Module 6: Computational Intelligence Programming
Module prerequisites	Module 2: Stochastic Signals and Systems
Module examination requirements	None
Module examination	Written project report (submission period 8 weeks, processing time 20 hours) and presentation (min. 5, max. 10 minutes).
Learning outcomes and skills	Upon completion of the module the students are able to: • explain, compare and choose machine learning algorithms, • predict the efficiency of machine learning strategies, integrate existing and new knowledge, • handle complexity, even on the basis of limited information, • acquire new knowledge and skills independently, • develop research questions, • choose adequate ways of operationalizing research and explain their choices, • explain research results and interpret them critically, • present problem solutions in a structured manner, • communicate their conclusions, and the acquired knowledge to specialist and non-specialist audiences in a clear and unambiguous way, • evaluate the social economic and ethical consequences of deep learning.
Module contents	Machine Learning Project
Module teaching methods	Project
Module language	English
Module availability	Winter semester
Module coordination	Prof. Dr. Andreas Pech

Comments	None

Unit 7.1: Machine Learning Project

Unit title	Machine Learning Project
Code	
Module title	Machine Learning
Unit contents	Individual Project
Teaching methods	Project
Semester periods (hours) per week	2 h
Workload (h)	150 h
Class hours	30 h
Total time of examination incl. preparation (h)	The individual study (see below) includes the time of examination incl. preparation
Total time of individual study (h)	120 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Pech
Recommended reading	Kubat, M.: An Introduction To Machine Learning, Springer 2017. Goodfellow, I.; Bengio, Y.; Courville, A.: Deep Learning, MIT Press 2016.
Assessment type and form of	
Assessment grading	
Comments	

Module 8

Module title	Mobile Computing
Module number	8
Module code	Module code
Study program	Information Technology (dreisemestrig)
Module usability	Information Technology (viersemestrig)
Module duration	One semester
Recommended semester	2nd semester
Module type	Compulsory module
ECTS (CP) / Workload (h)	5 CP / 150 h
Recommended previous knowledge	Recommended prerequisites: Modul 1 – Methods, Systems and Networks for Digital Communication, Module 3 – Software Engineering, Module 11 – Digital Switching and Routing
Module prerequisites	None
Module examination requirements	None
Module examination	Documentation of software (submission period 10 weeks, processing time 20 hours) and presentation (min. 15, max. 20 minutes)
Learning outcomes and skills	Upon completion of the module the students are able to: • define and interpret the special features, limits, terminologies and schools of thought in the area of mobile computing communication technologies, GSM/UMTS cellular mobile networks, 5 G incl. NFV and SDN • communicate project results, conclusions as well as the underlying assumptions and reasoning to a specialist audience • manage an application-oriented project acc. to Mobile Computing topics in a largely self-directed manner • assess the ethical and societal dimensions of ubiquitous computing
Module contents	Lectures in Mobile Computing Mobile Computing Project incl. Presentation
Module teaching methods	Lectures Project
Module language	English
Module availability	Winter semester
Module coordination	Trick
Comments	

Unit 8.1: Lectures in Mobile Computing

Unit title	Lectures in Mobile Computing
Code	
Module title	Mobile Computing
Unit contents	Areas acc. to Mobile Computing, types of mobility, handover/roaming, mobility support at various layers, Mobile Computing communication technologies, GSM/UMTS cellular mobile networks, 5G incl. NFV (Network Functions Virtualisation), SDN (Software Defined Networking) Presentations on topics of Mobile Computing
Teaching methods	Lecture
Semester periods (hours) per week	2
Workload (h)	45 h
Class hours	30 h
Total time of examination incl. preparation (h)	0 h
Total time of individual study (h)	15 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Trick
Recommended reading	Trick, Ulrich; Weber, Frank: SIP und Telekommunikationsnetze – Next Generation Networks und Multimedia over IP – konkret. De Gruyter Oldenbourg, 2015 Kamal, Devi: Mobile Computing. Oxford Univ. Pr., 2012 Zhang, Ying: Network function virtualization – Concepts and applicability in 5G Networks, Wiley, 2018 3GPP standards ETSI standards ITU-T standards Additional up-to-date reading information will be announced at the beginning of the lecture.
Assessment type and form of	
Assessment grading	
Comments	

Unit 8.2: Mobile Computing Project

Unit title	Mobile Computing Project
Code	
Module title	Mobile Computing
Unit contents	Individual Mobile Computing Project
Teaching methods	Project
Semester periods (hours) per week	1
Workload (h)	105 h
Class hours	15 h
Total time of examination incl. preparation (h)	0 h
Total time of individual study (h)	45 h
Total time of practical training (h)	45 h
Unit language	English
Lecturer	Trick
Recommended reading	Trick, Ulrich; Weber, Frank: SIP und Telekommunikationsnetze – Next Generation Networks und Multimedia over IP – konkret. De Gruyter Oldenbourg, 2015 Kamal, Devi: Mobile Computing. Oxford Univ. Pr., 2012 Zhang, Ying: Network function virtualization – Concepts and applicability in 5G Networks, Wiley, 2018 3GPP standards ETSI standards ITU-T standards Worksheets Additional up-to-date reading information will be announced at the beginning of the lecture.
Assessment type and form of	
Assessment grading	
Comments	

Module 9

Module title	Field Theory for Optical and Microwave Systems
Module number	9
Module code	
Study program	Information Technology (dreisemestrig)
Module usability	Information Technology (viersemestrig)
Module duration	One semester
Recommended semester	2nd semester
Module type	Compulsory module
ECTS (CP) / Workload (h)	5 CP / 150 h
Recommended previous knowledge	Vector analysis
Module prerequisites	None
Module examination requirements	None
Module examination	Written examination, 90 minutes
Learning outcomes and skills	By the end of the course, students are able to: • explain Maxwell's Equations, • formulate all boundary conditions, • formulate and solve the wave equation of a plane wave, • classify different wave solutions, • explain the modes of different wavequides • explain radiation of different antennas
Module contents	Lecture of Field Theory and Microwave Systems
Module teaching methods	Lecture, exercises
Module language	English
Module availability	Summer semester
Module coordination	Prof. Dr.-Ing. Gernot Zimmer
Comments	None

Unit 9.1: Field Theory for Optical and Microwave Systems Lecture

Unit title	Field Theory for Optical and Microwave Systems Lecture
Code	
Module title	Field Theory for Optical and Microwave Systems
Unit contents	• Introduction to Microwave and optical Systems,

	• History and application of electromagnetic spectrum, • Maxwell's equation in time and frequency domain, • constitutive relations, • boundary conditions, • plane wave, • Poynting vector, • classification of waves, • TEM TM and TE modes in different structures, • Hertzian dipol, • Radiation of linear and aperture antennas
Teaching methods	Lecture combined with exercises
Semester periods (hours) per week	4
Workload (h)	150 h
Class hours	60 h (of which exercises 15 h)
Total time of examination incl. preparation (h)	0 h
Total time of individual study (h)	90 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Zimmer
Recommended reading	Collin, R.E.: Foundations for microwave engineering, McGraw Hill, NewYork Olver, A. D.: Microwave and Optical Transmission, John Wiley, New York Unger, H. G.: Elektromagnetische Theorie für die Hochfrequenztechnik, Hüthig-Verlag Additional up-to-date reading information will be provided at the beginning of the lecture.
Assessment type and form of	
Assessment grading	
Comments	

Module 10

Module title	Autonomous Intelligent Systems
Module number	10
Module code	
Study program	Information Technology (dreisemestrig)
Module usability	Information Technology (viersemestrig)
Module duration	One semester
Recommended semester	2nd semester
Module type	Compulsory module
ECTS (CP) / Workload (h)	5 CP / 150 h
Recommended previous knowledge	None
Module prerequisites	None
Module examination requirements	None
Module examination	Project report (submission period 14 weeks, processing time 20 hours)
Learning outcomes and skills	Upon completion of the module the students are able to: • identify and explain the architecture, hardware and software of autonomous systems, • generate intelligent algorithms and apply them to intelligent sensors, action planning and decision making, • structure, write and deliver a project report within a given timeframe, • judge the impact of decision making in autonomous systems on society, • evaluate the social-economic consequences of an industry highly automated by autonomous systems.
Module contents	Lectures in Autonomous Intelligent Systems Project in Autonomous Intelligent Systems
Module teaching methods	Lectures and project
Module language	English
Module availability	Winter semester
Module coordination	Prof. Dr. P. Nauth
Comments	

Unit 10.1: Lectures in Autonomous Intelligent Systems

Unit title	Lectures in Autonomous Intelligent Systems
Code	
Module title	Autonomous Intelligent Systems
Unit contents	Autonomous Systems: • Architecture, • hardware, • environmental sensing, • sensor fusion, • autonomous decision making, • planning, plan execution, • human machine interaction, • programming of autonomous systems Intelligent Sensors for Autonomous Systems: • Technology and characteristics of microcontrollers for intelligent sensors, • design of intelligent sensors, • programming of algorithms for signal processing and pattern recognition, • examples of intelligent sensors for applications in autonomous systems Actors: • Types of actors, actor control
Teaching methods	Lecture
Semester periods (hours) per week	2
Workload (h)	45 h
Class hours	30 h
Total time of examination incl. preparation (h)	0 h
Total time of individual study (h)	15 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Prof. Dr. P. Nauth
Recommended reading	H.-N.Teodorescu, D.Mlynek, A.Kandel, H.-J.Zimmermann: Intelligent Systems and Interfaces, Springer Verlag, 2000 P. Nauth: Embedded Intelligent Systems, Oldenbourg Verlag, 2005 Additional up-to-date reading information will be provided at the

	beginning of the lecture.
Assessment type and form of	
Assessment grading	
Comments	

Unit 10.2: Project in Autonomous Intelligent Systems

Unit title	Project in Autonomous Intelligent Systems
Code	
Module title	Autonomous Intelligent Systems
Unit contents	Projects regarding design, programming and application of autonomous systems
Teaching methods	Project
Semester periods (hours) per week	1
Workload (h)	105 h
Class hours	15 h
Total time of examination incl. preparation (h)	The self-study (see below) includes the preparation for the module examination.
Total time of individual study (h)	90 h
Total time of practical training (h)	The self-study and contact time (see above) includes the practical training.
Unit language	English
Lecturer	Prof. Dr. Nauth
Recommended reading	H.-N. Teodorescu, D. Mlynek, A. Kandel, H.-J. Zimmermann: Intelligent Systems and Interfaces, Springer Verlag, 2000 P. Nauth: Embedded Intelligent Systems, Oldenbourg Verlag, 2005 Worksheets
Assessment type and form of	
Assessment grading	
Comments	

Optional Module 11.1

Module title	Engineering of Microwave Systems
Module number	11.1
Module code	
Study program	Information Technology (dreisemestrig)
Module usability	Information Technology (viersemestrig)
Module duration	One semester
Recommended semester	2nd semester
Module type	Elective module
ECTS (CP) / Workload (h)	5 CP / 150 h
Recommended previous knowledge	Circuit Design for Communication Systems
Module prerequisites	None
Module examination requirements	None
Module examination	Written project report (submission period 8 weeks, processing time 20 hours) with presentation (min. 10, max. 20 minutes)
Learning outcomes and skills	Upon completion of the module the students are able to: • describe, explain and compare different system architectures in the field of microwaves • identify the requirements of a selected system architecture and illustrate the design process • communicate project results, conclusions as well as the underlying assumptions and reasoning to a specialist audience • to do independent work in the domain of microwave engineering.
Module contents	Engineering of Microwave Systems Lecture Engineering of Microwave Systems Project
Module teaching methods	Lecture, project
Module language	English
Module availability	Winter semester
Module coordination	Prof. Dr.-Ing. Gernot Zimmer
Comments	None

Unit 11.1.1: Engineering of Microwave Systems Lecture

Unit title	Engineering of Microwave Systems Lecture
Code	

Module title	Engineering of Microwave Systems
Unit contents	System architecture of different microwave systems e.g. Wireless LANs, microwave sensors; component requirements to design and build the physical layers
Teaching methods	Lecture
Semester periods (hours) per week	3
Workload (h)	45 h
Class hours	45 h
Total time of examination incl. preparation (h)	0 h
Total time of individual study (h)	0 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Zimmer
Recommended reading	Collin, R.E.: Foundations for microwave engineering, McGraw Hill, NewYork Olver, A. D.: Microwave and Optical Transmission, John Wiley, New York Unger, H. G.: Elektromagnetische Theorie für die Hochfrequenztechnik, Hüthig-Verlag Additional up-to-date reading information will be provided at the beginning of the lecture.
Assessment type and form of	
Assessment grading	
Comments	

Unit 11.1.2: Engineering of Microwave System Project

Unit title	Engineering of Microwave System Project
Code	
Module title	Engineering of Microwave System
Unit contents	Application of Microwave Engineering models and methods
Teaching methods	Project
Semester periods (hours) per week	1

Workload (h)	105 h
Class hours	15 h
Total time of examination incl. preparation (h)	The individual study (see below) includes the time of examination incl. preparation
Total time of individual study (h)	75 h
Total time of practical training (h)	15 h
Unit language	English
Lecturer	Zimmer
Recommended reading	Collin, R.E.: Foundations for microwave engineering, McGraw Hill, NewYork Olver, A. D.: Microwave and Optical Transmission, John Wiley, New York Unger, H. G.: Elektromagnetische Theorie für die Hochfrequenztechnik, Hüthig-Verlag Additional up-to-date reading information will be provided at the beginning of the lecture.
Assessment type and form of	
Assessment grading	
Comments	

Optional Module 11.2

Module title	Engineering of Optical Systems
Module number	11.2
Module code	
Study program	Information Technology (dreisemestrig)
Module usability	Information Technology (viersemestrig)
Module duration	One semester
Recommended semester	2nd semester
Module type	Elective module
ECTS (CP) / Workload (h)	5 CP / 150 h
Recommended previous knowledge	Circuit Design for Communication Systems
Module prerequisites	None
Module examination requirements	None
Module examination	Written project report (submission period 8 weeks, processing time 20 hours) with presentation (min. 10, max. 20 minutes)
Learning outcomes and skills	Students acquire knowledge of different theoretical system architectures in the field of optics. They understand the design process and the requirements of the selected system architectures. They acquire practical knowledge to develop computer supported optical design. On successful completion of the Module the students are able to: • Calculate and measure system parameters of optical systems • Research appropriate information to perform requirements specification • Analyze and optimize optical systems • Consider the different specifications of optical systems and realize a computer supported optical systems They are able to organize a technical project and work together in a team. They are able to present and discuss the approach.
Module contents	Engineering of Optical Systems Lecture Engineering of Optical Systems Project
Module teaching methods	Lecture, project
Module language	English
Module availability	Winter semester
Module coordination	Prof. Dr.-Ing. Gernot Zimmer

Comments	None

Unit 11.2.1: Engineering of Optical Systems Lecture

Unit title	Engineering of Optical Systems Lecture
Code	
Module title	Engineering of Optical Systems
Unit contents	Selected system architectures in the domain of optical engineering e.g. modulation and noise behaviour of semiconductor lasers and photo detectors; system architecture of different optical systems e.g. optical LANs or optical sensors; component requirements to design and build the physical layers
Teaching methods	Lecture
Semester periods (hours) per week	3
Workload (h)	45 h
Class hours	45 h
Total time of examination incl. preparation (h)	0 h
Total time of individual study (h)	0 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Zimmer
Recommended reading	Collin, R.E.: Foundations for microwave engineering, McGraw Hill, NewYork Olver, A. D.: Microwave and Optical Transmission, John Wiley, New York Additional up-to-date reading information will be provided at the beginning of the lecture.
Assessment type and form of	
Assessment grading	
Comments	

Unit 11.2.2: Engineering of Optical Systems Project

Unit title	Engineering of Optical Systems Project
Code	

Module title	Engineering of Optical Systems
Unit contents	Application of Optical Engineering models and methods
Teaching methods	Project
Semester periods (hours) per week	1
Workload (h)	105 h
Class hours	15 h
Total time of examination incl. preparation (h)	The individual study (see below) includes the time of examination incl. preparation
Total time of individual study (h)	75 h
Total time of practical training (h)	15 h
Unit language	English
Lecturer	Zimmer
Recommended reading	Collin, R.E.: Foundations for microwave engineering, McGraw Hill, NewYork Olver, A. D.: Microwave and Optical Transmission, John Wiley, New York Additional up-to-date reading information will be provided at the beginning of the lecture.
Assessment type and form of	
Assessment grading	
Comments	

Module 12

Module title	Project
Module number	12
Module code	
Study program	Information Technology (dreisemestrig)
Module usability	Information Technology (viersemestrig)
Module duration	One semester
Recommended semester	2nd semester
Module type	Compulsory module
ECTS (CP) / Workload (h)	5 CP / 150 h
Recommended previous knowledge	
Module prerequisites	None
Module examination requirements	None
Module examination	Written project report (submission period 22 weeks, processing time 20 hours) with presentation (min. 10, max. 20 minutes)
Learning outcomes and skills	Upon completion of the module the students are able to • do requirements engineering and to evolve problem solution strategies, • present technical projects to an expert audience, • integrate existing and new knowledge, • handle complexity, even on the basis of limited information, • acquire new knowledge and skills independently, • develop research questions, choose adequate ways of operationalizing research and explain their choices, • explain research results and interpret them critically, • respect cultural and social aspects of project work in international R&D teams.
Module contents	Project
Module teaching methods	Project
Module language	English
Module availability	Every semester
Module coordination	Prof. Dr. Andreas Pech
Comments	None

Unit 12.1: Project

Unit title	Project
Code	
Module title	Project
Unit contents	Depending on project subject
Teaching methods	Project
Semester periods (hours) per week	0 h
Workload (h)	150 h
Class hours	0 h
Total time of examination incl. preparation (h)	0 h
Total time of individual study (h)	150 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	Pech
Recommended reading	
Assessment type and form of	
Assessment grading	
Comments	

Module 13

Module title	Master Thesis and Colloquium
Module number	13
Module code	
Study program	Information Technology (dreisemestrig)
Module usability	Information Technology (viersemestrig)
Module duration	One semester
Recommended semester	3rd semester
Module type	Compulsory module
ECTS (CP) / Workload (h)	30 CP / 900 h
Recommended previous knowledge	
Module prerequisites	Successful completion of modules A to F and 1 to 12
Module examination requirements	None
Module examination	Documentation of Master Thesis (processing time 22 weeks) and colloquium (min. 30, max. 45 minutes)
Learning outcomes and skills	Upon completion of the master thesis the student is able to: • plan, organize, develop, operate and present information technology systems answering to real world requirements. • assess the science-based correctness by weighing up scientific and methodological considerations. • solve practical and scientific problems by taking into account these considerations.
Module contents	Master Thesis
Module teaching methods	Master Thesis
Module language	English
Module availability	Every semester
Module coordination	Prof. Dr. Andreas Pech
Comments	None

Unit 13.1: Master Thesis

Unit title	Master Thesis
Code	
Module title	Master Thesis and Colloquium

Unit contents	Depending on master thesis subject
Teaching methods	Master Thesis
Semester periods (hours) per week	0 h
Workload (h)	880 h
Class hours	0 h
Total time of examination incl. preparation (h)	0 h
Total time of individual study (h)	0 h
Total time of practical training (h)	0 h
Unit language	English
Lecturer	All professors of the Information Technology program
Recommended reading	
Assessment type and form of	
Assessment grading	
Comments	

Unit 13.2: Colloquium

Unit title	Colloquium
Code	
Module title	Master Thesis and Colloquium
Unit contents	Colloquium
Teaching methods	
Semester periods (hours) per week	0 h
Workload (h)	20 h
Class hours	0 h
Total time of examination incl. preparation (h)	20 h
Total time of individual study (h)	0 h
Total time of practical training (h)	0 h
Unit language	English

Lecturer	All professors of the Information Technology program
Recommended reading	
Assessment type and form of	
Assessment grading	
Comments	