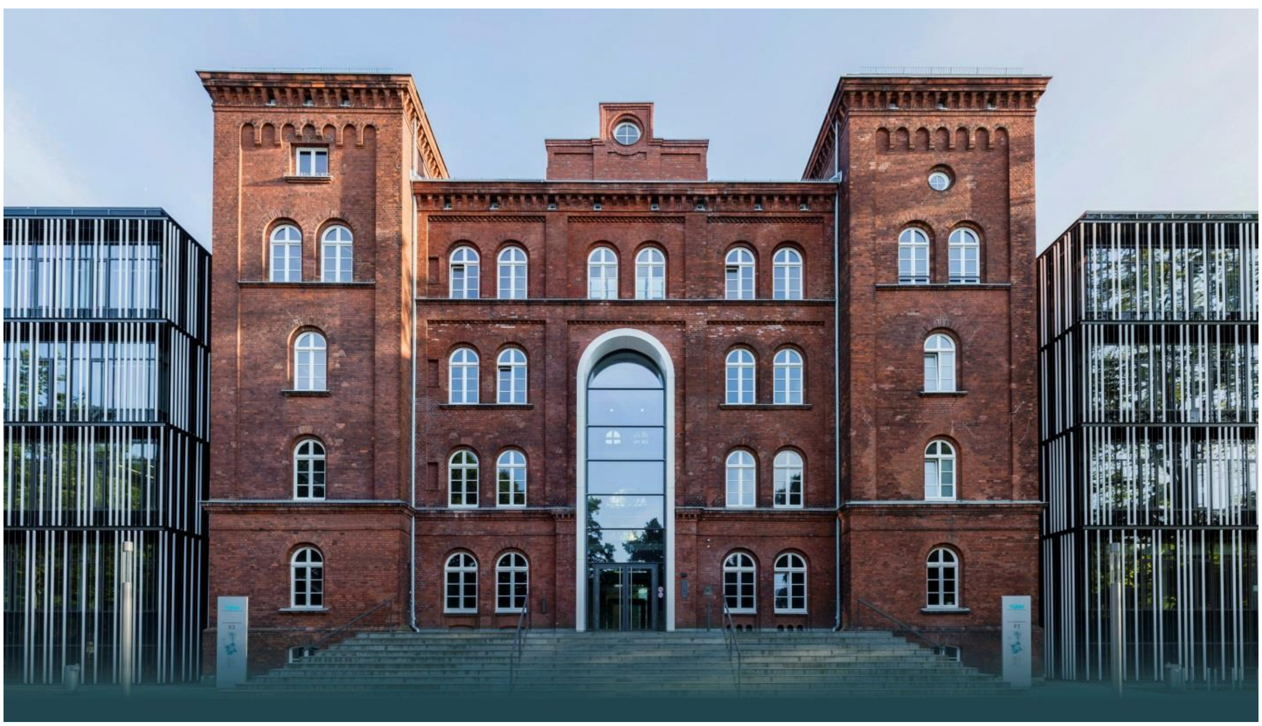
Electrical Engineering, Computer Science and Mathematics

Courses leading to a Master's degree, taught in English



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Dear Erasmus students,

welcome to Hamburg University of Technology (TUHH). We are a small but high-class university with a clear profile in research and with modern, practice-oriented learning methods. The School of Electrical Engineering, Computer Science and Mathematics offers a wide selection of ambitious classes at Master and Bachelor level. The intent of this brochure is to guide students of the European exchange program ERASMUS through their academic studies at TUHH.

The academic calendar in Germany differs from that of other European countries. The German academic year is divided into two semesters: the Wintersemester (WS) from October 1st to March 31st and the Sommersemester (SS) from April 1st to September 30th. Each semester consists of 14 weeks during which classes take place and a period when there are usually no classes. The first period is called Vorlesungszeit and the second vorlesungsfreie Zeit. The final exams for the classes are during the vorlesungsfreie Zeit. The periods of the Vorlesungszeit slightly vary from year to year. The exact dates you will find on the website of TUHH. In the WS, the Vorlesungszeit at TUHH begins in mid-October and ends in the middle of February with a break of about two weeks around Christmas. In the SS TUHH classes start at the beginning of April until middle of July with a break of one week after Pentecost.

All courses are either taught in the Wintersemester or in the Sommersemester. One exception to this rule are language courses. This brochure contains a list of all courses of the School of Electrical Engineering, Computer Science and Mathematics of our Master programs that are taught in English. There are also a few courses that are only taught in German, they are not listed. The list gives a short overview about the content of each course. The list is divided into two parts: courses of the winter term and of the summer term You also find the name of the lecture. You may also participate in courses taught by other faculties and languages courses. You will find information about these courses on TUHH's website.

The lecture rooms and the lecturing times vary from year to year, again please have a look at the website. In rare cases lectures of different courses may be given at the same time. In this case you have to change your course selection after your arrival in Hamburg. We advise you to participate in a German language course. This will enable you to get an insight into the German culture to get the most out of your stay.

Exams are held during the vorlesungsfreie Zeit. On occasion ERASMUS students have to be at their home university at that time. In this case it is advisable to contact the lecturer of the corresponding class and ask for alternatives.

For all questions regarding your academic stay in Hamburg please consult the International Office of TUHH. It provides a wealth of information through their web site at https://www.tuhh.de/alt/tuhh/education/contacts/international-office.html.

We hope that your stay at TUHH enriches your scientific and cultural views of the planet and we look forward to welcoming you in Hamburg!

Prof. V. Turau
ERAMUS coordinator
School of Electrical Engineering, Computer Science and Mathematics

List of Lectures

SUMMER TERM

SUMMER TERM

Course	Contents	Institute/Lecturer Period
	SUMMER TERM	
Medical Technology Lab 6 ECTS 6 SWS	The actual project topic will be defined as part of the project.	E-1 Prof. Dr. Alexander Schlaefer Summer Term
Robotics and Navigation in Medicine Lecture, Exercise, Seminar 6 ECTS 5 SWS	The students can explain kinematics and tracking systems in clinical contexts and illustrate systems and their components in detail. Systems can be evaluated with respect to collision detection and safety and regulations. Students can assess typical systems regarding design and limitations.	E-1 Prof. Dr. Alexander Schlaefer Summer Term
Seminar Medical Technology 2 ECTS, 2 SWS	• Review of a recent scientific publication • presentation skills	E-1 Prof. Dr. Alexander Schlaefer Summer Term Winter Term
Pattern Recognition and Data Compression Lecture 6 ECTS 4 SWS	Students can name the basic concepts of pattern recognition and data compression. Taking place for the last time in summer 2021 Students are able to discuss logical connections between the concepts covered in the course and to explain them by means of examples.	E-2 Prof. Dr. Rolf-Rainer Grigat Summer Term
Simulation of Communication Networks Lab 6 ECTS 5 SWS	Students are able to explain the necessary stochastics, the discrete event simulation technology and modelling of networks for performance evaluation.	E-4 Prof. Dr. Andreas Timm-Giel Summer Term

Course	Contents	Institute/Lecturer Period
Computer Graphics Lecture, Lab 6 ECTS 4 SWS	Students can explain and describe basic algorithms in 3D computer graphics. Students are capable of • implementing a basic 3D rendering pipeline. This consists of projecting simple 3D structures (e.g. cube, spheres) onto a 2D surface using a virtual camera. • apply geometric transformations (e.g. rotation, scaling) in 2D and 3D computer graphics. • using well-known 2D/3D APIs (OpenGL, Cairo) for solving a given problem statement.	E-5 Prof. Dr. Tobias Knopp Summer Term
Process Measurement Engineering Lecture, Exercise 4 ECTS 3 SWS	The students possess an understanding of complex, state-of-the-art process measurement equipment. They can relate devices and procedures to a variety of commonly used measurement and communications technology. The students are capable of modeling and evaluating complex systems of sensing devices as well as associated communications systems. An emphasis is placed on a system-oriented understanding of the measurement equipment.	E-6 Prof. Dr. Roland Harig Summer Term
Microsystem Design Lecture, Lab 6 ECTS 5 SWS	The students know about the most important and most common simulation and design methods used in microsystem design. The scientific background of finite element methods and the basic theory of these methods are known. Students are able to apply simulation methods and commercial simulators in a goal oriented approach to complex design tasks. Students know to apply the theory in order achieve estimates of expected accuracy and can judge and verify the correctness of results. Students are able to develop a design approach even if only incomplete information about material data or constraints are available. Student can make use of approximate and reduced order models in a preliminary design stage or a system simulation.	E-7 Prof. Dr. Manfred Kasper Summer Term
Semiconductor Technology Lecture, Lab 7 ECTS	Students are able • to describe and to explain current fabrication techniques for Si and GaAs substrates, • to discuss in details the relevant fabrication processes, process flows and the impact thereof on	E-7 Prof. Dr. Hoc Khiem Trieu Summer Term

Course	Contents	Institute/Lecturer Period
6 SWS	the fabrication of semiconductor devices and integrated circuits and • to present integrated process flows.	
Advanced Concepts of Wireless Communications Lecture, Exercise 6 ECTS 4 SWS	Students are able to explain the general as well as advanced principles and techniques that are applied to wireless communications. They understand the properties of wireless channels and the corresponding mathematical description. Furthermore, students are able to explain the physical layer of wireless transmission systems. In this context, they are proficient in the concepts of multicarrier transmission (OFDM), modulation, error control coding, channel estimation and multi-antenna techniques (MIMO). Students can also explain methods of multiple access. On the example of contemporary communication systems (UMTS, LTE) they can put the learnt content into a larger context. Using the acquired knowledge, students are able to understand the design of current and future wireless systems. Moreover, given certain constraints, they can choose appropriate parameter settings of communication systems. Students are also able to assess the suitability of technical concepts for a given application.	E-8 Dr. Rainer Grünheid Summer Term
Information Theory and Coding Lecture, Exercise 6 ECTS 4 SWS	The students know the basic definitions for quantification of information in the sense of information theory. They know Shannon's source coding theorem and channel coding theorem and are able to determine theoretical limits of data compression and error-free data transmission over noisy channels. They understand the principles of source coding as well as error-detecting and error-correcting channel coding. They are familiar with the principles of decoding, in particular with modern methods of iterative decoding. They know fundamental coding schemes, their properties and decoding algorithms. The students are able to determine the limits of data compression as well as of data transmission through noisy channels and based on those limits to design basic parameters of a transmission scheme. They can estimate the parameters of an error-detecting or error-correcting channel coding scheme for achieving certain performance targets. They are able to compare the properties of basic channel coding and decoding schemes regarding error correction capabilities, decoding delay, decoding complexity and to decide for a suitable method. They are capable of implementing basic coding and decoding schemes in software.	E-8 Prof. Dr. Gerhard Bauch Summer Term

Course	Contents	Institute/Lecturer Period
Seminar Communications Engineering 2 ECTS, 2 SWS	• Each participant chooses a topic out of a list of possible subjects and prepares a presentation for the seminar. Close contact with the supervisor is required.	E-8 Prof. Dr. Gerhard Bauch Summer Term Winter Term
Advanced IC Design Lecture, Excercise 6 ECTS 4 SWS	• Students can explain the basic structure of the circuit simulator SPICE. • Students are able to describe the differences between the MOS transistor models of the circuit simulator SPICE. • Students can discuss the different concept for realization the hardware of electronic circuits. • Students can exemplify the approaches for “Design for Testability”. • Students can specify models for calculation of the reliability of electronic circuits.	E-9 Prof. Dr. Matthias Kuhl Summer Term
Digital Circuit Design Lecture 6 ECTS 4 SWS	• To be done	E-9 Prof. Dr. Matthias Kuhl Summer Term Winter Term
Laboratory: Digital Circuit Design Lab 6 ECTS 4 SWS	• Students can explain the structure and philosophy of the software framework for circuit design. • Students can determine all necessary input parameters for circuit simulation. • Students are able to explain the functions of the logic gates of their digital design. • Students can explain the algorithms of checking routines. • Students are able to select the appropriate transistor models for fast and accurate simulations.	E-9 Prof. Dr. Matthias Kuhl Summer Term
Semiconductor Seminar 2 ECTS 2 SWS	• Students can explain the most important facts and relationships of a specific topic from the field of semiconductors.	E-9 Prof. Dr. Matthias Kuhl Summer Term
Approximation and Stability Lecture, Exercise, Seminar 6 ECTS 4 SWS	Students are able to • sketch and interrelate basic concepts of functional analysis (Hilbert space, operators), • name and understand concrete approximation methods, • name and explain basic stability theorems, • discuss spectral quantities, conditions numbers and methods of regularisation • apply basic results from functional analysis,	E-10 Prof. Dr. Marko Lindner Summer Term

Course	Contents	Institute/Lecturer Period
	• apply approximation methods, • apply stability theorems, • compute spectral quantities, • apply regularisation methods.	
Numerical Mathematics II Lecture, Exercise 6 ECTS 4 SWS	Students are able to • name advanced numerical methods for interpolation, integration, linear least squares problems, eigenvalue problems, nonlinear root finding problems and explain their core ideas, • repeat convergence statements for the numerical methods, • sketch convergence proofs, • explain practical aspects of numerical methods concerning runtime and storage needs • explain aspects regarding the practical implementation of numerical methods with respect to computational and storage complexity. • implement, apply and compare advanced numerical methods in MATLAB, • justify the convergence behaviour of numerical methods with respect to the problem and solution algorithm and to transfer it to related problems, • for a given problem, develop a suitable solution approach, if necessary through composition of several algorithms, to execute this approach and to critically evaluate the results	E-10 Prof. Dr. Sabine Le Borne Summer Term
Numerical treatment of ordinary differential equations Lecture, Exercise 6 ECTS 4 SWS	Students are able to • list numerical methods for the solution of ordinary differential equations and explain their core ideas, • repeat convergence statements for the treated numerical methods (including the prerequisites tied to the underlying problem), • explain aspects regarding the practical execution of a method. • select the appropriate numerical method for concrete problems, implement the numerical algorithms efficiently and interpret the numerical results • implement (MATLAB), apply and compare numerical methods for the solution of ordinary differential equations,	E-10 Prof. Dr. Daniel Ruprecht Summer Term

Course	Contents	Institute/Lecturer Period
	• to justify the convergence behaviour of numerical methods with respect to the posed problem and selected algorithm, • for a given problem, develop a suitable solution approach, if necessary by the composition of several algorithms, to execute this approach and to critically evaluate the results.	
Randomized Algorithms and Random Graphs Lecture, Excercise 6 ECTS 4 SWS	• Students can describe basic concepts in the area of Randomized Algorithms and Random Graphs such as random walks, tail bounds, fingerprinting and algebraic techniques, first and second moment methods, and various random graph models. • They are able to explain them using appropriate examples. • Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples. • They know proof strategies and can apply them.	E-10 Prof. Dr. Anusch Taraz E-17 Prof. Dr. Volker Turau Summer Term
Solvers for sparse linear systems Lecture, Exercise 6 ECTS 4 SWS	• list classical and modern iteration methods and their interrelationships, • repeat convergence statements for iteration methods, • explain aspects regarding the efficient implementation of iteration methods.	E-10 Prof. Dr. Sabine Le Borne Summer Term
Optical Communications Lecture, Exercise 4 ECTS 3 SWS	The aim of this course is imparting profound knowledge and analytical skills in the following fields: • Fundamentals of Optical Waveguiding • Properties of Optical Silica Fibers • Passive Components for Optical Communications • Fundamentals of Photodiodes and LEDs • Noise in Photodetectors • Laser Diodes • Optical Amplifiers • Nonlinearities in Optical Fibers • Optical Communication Systems	E-12 Dr. Hagen Renner Summer Term
Fibre and Integrated Optics Lecture, Exercise 4 ECTS 3 SWS	Students can explain the fundamental mathematical and physical relations and technological basics of guided optical waves. They can describe integrated optical as well as fibre optical structures. They can give an overview on the applications of integrated optical components in optical signal processing.	E-12 Prof. Dr. Manfred Eich Summer Term
Optoelectronics I: Wave	Students can explain the fundamental mathematical and	E-12

Course	Contents	Institute/Lecturer Period
Optics Lecture, Exercise 4 ECTS 3 SWS	physical relations of freely propagating optical waves. They can give an overview on wave optical phenomena such as diffraction, reflection and refraction, etc. Students can describe waveoptics based components such as electrooptical modulators in an application oriented way.	Prof. Dr. Manfred Eich Summer Term
Curves, Codes and Cryptosystems Lecture 6 ECTS 4 SWS	The students understand the basic theory of elliptic curves, classical cryptosysteme, basic methods of cryptanalysis, cryptography of elliptic curves, quantum computing and the post-quantum computing scenario. Taking place for the last time in summer 2022	E-13 Prof. Dr. Karl-Heinz Zimmermann Summer Term
Compilers for Embedded Systems Lecture, Lab 6 ECTS 4 SWS	The relevance of embedded systems increases from year to year. Within such systems, the amount of software to be executed on embedded processors grows continuously due to its lower costs and higher flexibility. Because of the particular application areas of embedded systems, highly optimized and application-specific processors are deployed. Such highly specialized processors impose high demands on compilers which have to generate code of highest quality. After the successful attendance of this course, the students are able • to illustrate the structure and organization of such compilers, • to distinguish and explain intermediate representations of various abstraction levels, and • to assess optimizations and their underlying problems in all compiler phases. The high demands on compilers for embedded systems make effective code optimizations mandatory. The students learn in particular, • which kinds of optimizations are applicable at the source code level, • how the translation from source code to assembly code is performed, • which kinds of optimizations are applicable at the assembly code level, • how register allocation is performed, and • how memory hierarchies can be exploited effectively. Since compilers for embedded systems often have to optimize for multiple objectives (e.g., average- or worst-case execution time, energy dissipation, code size), the students learn to evaluate the influence of optimizations on these different criteria.	E-13 Prof. Dr. Heiko Falk Summer Term

Course	Contents	Institute/Lecturer Period
Discrete Differential Geometry Lecture 6 ECTS 4 SWS	These lectures are on geometrical aspects of the solutions of differential equations and their treatment on the computer. The required basics from linear algebra and analysis are reviewed at the beginning. Applications are to curved surfaces in space, to mechanics and mechatronics, to different types of field equations, and to the tranfer of mathematical constructions to data types, compiler functions, programming languages, and special compute circuits. Taking place for the last time in summer 2022 • basic prerequisites from linear algebra, tensors, exterior algebra, Clifford algebras • basic prerequisites from coordinate-free analysis, vector fields and differential forms, integration, discretization • local differential geometry: connections, symplectic geometry and Hamiltonian systems, Riemannian geometry, discretization • global differential geometry: manifolds, Lie groups, fiber bundles, random processes, space and time	E-13 Prof. Dr. Karl-Heinz Zimmermann Summer Term
Design of Dependable Systems Lecture, Exercise 6 ECTS 4 SWS	In the following "dependable" summarizes the concepts Reliability, Availability, Maintainability, Safety and Security. Knowledge about approaches for designing dependable systems, e.g., • Structural solutions like modular redundancy • Algorithmic solutions like handling byzantine faults or checkpointing Knowledge about methods for the analysis of dependable systems	E-13 Prof. Dr. Görschwin Fey Summer Term
Model Checking - Proof Engines and Algorithms Lecture 6 ECTS 4 SWS	Students know • algorithms and data structures for model checking, • basics of Boolean reasoning engines and • the impact of specification and modelling on the computational effort for model checking.	E-13 Prof. Dr. Görschwin Fey Summer Term
Applied Humanoid Robotics Lecture, 6 ECTS	• Students can explain humanoid robots. • Students can explain the basic concepts, relationships and methods of forward- and inverse kinematics	E-14 Patrick Göttsch Summer Term

Course	Contents	Institute/Lecturer Period
6 SWS	• Students learn to apply basic control concepts for different tasks in humanoid robotics. • Students can implement models for humanoid robotic systems in Matlab and C++, and use these models for robot motion or other tasks. • They are capable of using models in Matlab for simulation and testing these models if necessary with C++ code on the real robot system. • They are capable of selecting methods for solving abstract problems, for which no standard methods are available, and apply it successfully.	
Humanoid Robotics Lab 2 ECTS, 2 SWS	• Students can explain humanoid robots. • Students learn to apply basic control concepts for different tasks in humanoid robotics. • Students acquire knowledge about selected aspects of humanoid robotics, based on specified literature • Students generalize developed results and present them to the participants • Students practice to prepare and give a presentation	E-14 Patrick Göttsch Summer Term
Linear and Nonlinear System Identification Lecture 3 ECTS 2 SWS	• Students can explain the general framework of the prediction error method and its application to a variety of linear and nonlinear model structures • They can explain how multilayer perceptron networks are used to model nonlinear dynamics • They can explain how an approximate predictive control scheme can be based on neural network models • They can explain the idea of subspace identification and its relation to Kalman realisation theory	E-14 Prof. Dr. Herbert Werner Summer Term
Optimal and Robust Control Lecture, Exercise 6 ECTS 4 SWS	• Students can explain the significance of the matrix Riccati equation for the solution of LQ problems. • They can explain the duality between optimal state feedback and optimal state estimation. • They can explain how the H2 and H-infinity norms are used to represent stability and performance constraints. • They can explain how an LQG design problem can be formulated as special case of an H2 design problem. • They can explain how model uncertainty can be represented in a way that lends itself to robust controller design • They can explain how - based on the small gain theorem - a robust controller can guarantee stability and performance for an uncertain plant.	E-14 Prof. Dr. Herbert Werner Summer Term

Course	Contents	Institute/Lecturer Period
	• They understand how analysis and synthesis conditions on feedback loops can be represented as linear matrix inequalities.	
Control Lab A 4 ECTS, 4 SWS	• Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that can be used for controller synthesis • They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers • They are capable of representing model uncertainty, and of designing and implementing a robust controller • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain-scheduled controllers	E-14 Prof. Dr. Herbert Werner Summer Term Winter Term
Control Lab B 2 ECTS, 2 SWS	• Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that can be used for controller synthesis • They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers • They are capable of representing model uncertainty, and of designing and implementing a robust controller • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain-scheduled controllers	E-14 Prof. Dr. Herbert Werner Summer Term Winter Term
Control Lab C 3 ECTS, 3 SWS	• Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that can be used for controller synthesis • They are capable of using standard software tools	E-14 Prof. Dr. Herbert Werner Summer Term Winter Term

Course	Contents	Institute/Lecturer Period
	(Matlab Control Toolbox) for the design and implementation of LQG controllers • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers • They are capable of representing model uncertainty, and of designing and implementing a robust controller • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain-scheduled controllers	
Seminar Advanced Topics in Control 2 ECTS, 2 SWS	• Students can explain modern control. • Students learn to apply basic control concepts for different tasks	E-14 Prof. Dr. Herbert Werner Summer Term Winter Term
Application Security Lecture, Exercise 6 ECTS 5 SWS	Taking place for the last time in summer 2020 • Email security • Web Services security • Security in Web applications • Access control • Trust Management • Trusted Computing • Digital Rights Management • Security Solutions for selected applications	E-15 Prof. Dr. Dieter Gollmann Summer Term
Machine Learning and Data Mining Lecture, Exercise 6 ECTS 4 SWS	Students can explain the difference between instance-based and model-based learning approaches, and they can enumerate basic machine learning technique for each of the two basic approaches, either on the basis of static data, or on the basis of incrementally incoming data . For dealing with uncertainty, students can describe suitable representation formalisms, and they explain how axioms, features, parameters, or structures used in these formalisms can be learned automatically with different algorithms. Students are also able to sketch different clustering techniques. They depict how the performance of learned classifiers can be improved by ensemble learning, and they can summarize how this influences computational learning theory. Algorithms for reinforcement learning can also be explained by students.	E-16 NN Summer Term
Software Testing Lecture, Exercise	Students explain the different phases of testing, describe fundamental techniques of different types of testing, and	E-16 Prof. Dr. Sybille

Course	Contents	Institute/Lecturer Period
6 ECTS 5 SWS	paraphrase the basic principles of the corresponding test process. They give examples of software development scenarios and the corresponding test type and technique. They explain algorithms used for particular testing techniques and describe possible advantages and limitations. Students identify the appropriate testing type and technique for a given problem. They adapt and execute respective algorithms to execute a concrete test technique properly. They interpret testing results and execute corresponding steps for proper re-test scenarios. They write and analyze test specifications. They apply bug finding techniques for non-trivial problems.	Schupp Summer Term
Introduction to Waveguides, Antennas and Electromagnetic Compatibility Lecture, Exercise 6 ECTS, 5 SWS	Students can explain the basic principles, relationships, and methods for the design of waveguides and antennas as well as of Electromagnetic Compatibility. Specific topics are: • Fundamental properties and phenomena of electrical circuits • Steady-state sinusoidal analysis of electrical circuits • Fundamental properties and phenomena of electromagnetic fields and waves • Steady-state sinusoidal description of electromagnetic fields and waves • Useful microwave network parameters • Transmission lines and basic results from transmission line theory • Plane wave propagation, superposition, reflection and refraction • General theory of waveguides • Most important types of waveguides and their properties • Radiation and basic antenna parameters • Most important types of antennas and their properties • Numerical techniques and CAD tools for waveguide and antenna design • Fundamentals of Electromagnetic Compatibility • Coupling mechanisms and countermeasures • Shielding, grounding, filtering • Standards and regulations • EMC measurement techniques	E-18 Prof. Dr. Christian Schuster Summer Term
Seminar on Electromagnetic Compatibility and Electrical Power Systems Seminar	• Current research topics in the fields electromagnetic compatibility, theory of electromagnetic fields, and electrical power systems	E-5 Prof. Dr. Christian Becker E-18 Prof. Dr. Christian Schuster Summer Term

Course	Contents	Institute/Lecturer Period
2 ECTS 2 SWS		Winter Term
Software for Embedded Systems Lecture, Exercise 6 ECTS 5 SWS	Students know the basic principles and procedures of software engineering for embedded systems. They are able to describe the usage and pros of event based programming using interrupts. They know the components and functions of a concrete microcontroller. The participants explain requirements of real time systems. They know at least three scheduling algorithms for real time operating systems including their pros and cons.	E-EXK2 Prof. Dr. Christian Renner Summer Term

WINTER TERM

Course	Contents	Institute/Lecturer Period
	WINTER TERM	
Industrial Process Automation Lecture and Exercise 6 ECTS 4 SWS	The students can evaluate and assess discrete event systems. They can evaluate properties of processes and explain methods for process analysis. The students can compare methods for process modelling and select an appropriate method for actual problems. They can discuss scheduling methods in the context of actual problems and give a detailed explanation of advantages and disadvantages of different programming methods. The students can relate process automation to methods from robotics and sensor systems as well as to recent topics like 'cyberphysical systems' and 'industry 4.0'.	E-1 Prof. Dr. Alexander Schlaefer Winter Term
Intelligent Systems in Medicine Lecture, Exercise, Seminar 6 ECTS 5 SWS	The students are able to analyze and solve clinical treatment planning and decision support problems using methods for search, optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy and safety requirements.	E-1 Prof. Dr. Alexander Schlaefer Winter Term
Seminar Medical Technology 2 ECTS, 2 SWS	• Review of a recent scientific publication	E-1 Prof. Dr. Alexander Schlaefer Winter Term Summer Term
3D Computer Vision Lecture, Exercise 6 ECTS 4 SWS	Students are capable of • Implementing an exemplary 3D or volumetric analysis task • Using highly sophisticated methods and procedures of the subject area • Identifying problems and • Developing and implementing creative solution suggestions. With assistance from the teacher students are able to link the contents of the three subject areas (modules) • Digital Image Analysis • Pattern Recognition and Data Compression and • 3D Computer Vision in practical assignments.	E-2 Prof. Dr. Rolf-Rainer Grigat Winter Term

Taking place for the last time in winter 21/22

Course	Contents	Institute/Lecturer Period
Digital Image Analysis Lecture 6 ECTS 4 SWS	Students can • Describe imaging processes • Depict the physics of sensorics • Explain linear and non-linear filtering of signals • Establish interdisciplinary connections in the subject area and arrange them in their context • Interpret effects of the most important classes of imaging sensors and displays using mathematical methods and physical models. Taking place for the last time in winter 21/22	E-2 Prof. Dr. Rolf-Rainer Grigat Winter Term
Communication Networks Lecture, Seminar, Exercise 6 ECTS 5 SWS	Students are able to describe the principles and structures of communication networks in detail. They can explain the formal description methods of communication networks and their protocols. They are able to explain how current and complex communication networks work and describe the current research in these examples.	E-4 Prof. Dr. Andreas Timm-Giel Winter Term
Traffic Engineering Lecture, Exercise, Seminar 6 ECTS 5 SWS	Students are able to describe methods for planning, optimisation and performance evaluation of communication networks.	E-4 Prof. Dr. Andreas Timm-Giel Winter Term
Microsystem Engineering Lecture, Exercise, Lab 6 ECTS 4 SWS	• The students know about the most important technologies and materials of MEMS as well as their applications in sensors and actuators. • Students are able to analyze and describe the functional behaviour of MEMS components and to evaluate the potential of microsystems.	E-7 Prof. Dr. Manfred Kasper Winter Term
Microsystem Technology in theory and practice Lecture, Lab 6 ECTS 4 SWS	Students are able • to present and to explain current fabrication techniques for microstructures and especially methods for the fabrication of microsensors and microactuators, as well as the integration thereof in more complex systems • to explain in details operation principles of microsensors and microactuators and • to discuss the potential and limitation of microsystems in application.	E-7 Prof. Dr. Hoc Khiem Trieu Winter Term
Digital Audio Signal Processing Lecture, Exercise 6 ECTS 3 SWS	The students will be able to apply methods and techniques from audio signal processing in the fields of mobile and internet communication. They can rely on elementary algorithms of audio signal processing in form of Matlab code and interactive JAVA applets. They can study parameter modifications and evaluate the	E-8 Prof. Dr. Udo Zölzer Winter Term

Course	Contents	Institute/Lecturer Period
	influence on human perception and technical applications in a variety of applications beyond audio signal processing. Students can perform measurements in time and frequency domain in order to give objective and subjective quality measures with respect to the methods and applications.	
Digital Communications Lecture, Exercise, Lab 6 ECTS 4 SWS	The students are able to understand, compare and design modern digital information transmission schemes. They are familiar with the properties of linear and non-linear digital modulation methods. They can describe distortions caused by transmission channels and design and evaluate detectors including channel estimation and equalization. They know the principles of single carrier transmission and multi-carrier transmission as well as the fundamentals of basic multiple access schemes.	E-8 Prof. Dr. Gerhard Bauch Winter Term
Digital Signal Processing and Digital Filters Lecture, Exercise 6 ECTS 4 SWS	The students know and understand basic algorithms of digital signal processing. They are familiar with the spectral transforms of discrete-time signals and are able to describe and analyse signals and systems in time and image domain. They know basic structures of digital filters and can identify and assess important properties including stability. They are aware of the effects caused by quantization of filter coefficients and signals. They are familiar with the basics of adaptive filters. They can perform traditional and parametric methods of spectrum estimation, also taking a limited observation window into account.	E-8 Prof. Dr. Gerhard Bauch Winter Term
Modern Wireless Systems Lecture 3 ECTS 2 SWS	Students have an overview of a variety of contemporary wireless systems of different size and complexity. They understand the technical solutions from the perspective of the physical and data link layer. They have developed a system view and are aware of the technical arguments, considering the respective applications and associated constraints. For several examples (e.g., Long Term Evolution, LTE), students are able to explain different concepts in a very deep technical detail.	E-8 Dr. Rainer Grünheid Winter Term
Seminar Communications Engineering 2 ECTS, 2 SWS	• Each participant chooses a topic out of a list of possible subjects and prepares a presentation for the seminar. Close contact with the supervisor is required.	E-8 Prof. Dr. Gerhard Bauch Summer Term Winter Term
Digital Circuit Design Lecture, Exercise 6 ECTS	• To be done	E-9 Prof. Dr. Matthias Kuhl

Course	Contents	Institute/Lecturer Period
4 SWS		Winter Term Summer Term
Electronic Circuits for Medical Applications Lecture, Exercise, Lab 6 ECTS 4 SWS Taking place for the last time in winter 21/22	• Students can explain the basic functionality of the information transfer by the central nervous system • Students are able to explain the build-up of an action potential and its propagation along an axon • Students can exemplify the communication between neurons and electronic devices • Students can describe the special features of low-noise amplifiers for medical applications • Students can explain the functions of prostheses, e. g. an artificial hand • Students are able to discuss the potential and limitations of cochlea implants and artificial eyes	E-9 Prof. Dr. Matthias Kuhl Winter Term
Integrated Circuit Design Lecture, Exercise 6 ECTS 4 SWS	• Students can explain basic concepts of electron transport in semiconductor devices (energy bands, generation/recombination, carrier concentrations, drift and diffusion current densities, semiconductor device equations). • Students are able to explain functional principles of pn-diodes, MOS capacitors, and MOSFETs using energy band diagrams. • Students can present and discuss current-voltage relationships and small-signal equivalent circuits of these devices. • Students can explain the physics and current-voltage behavior transistors based on charged carrier flow. • Students are able to explain the basic concepts for static and dynamic logic gates for integrated circuits • Students can exemplify approaches for low power consumption on the device and circuit level • Students can describe the potential and limitations of analytical expression for device and circuit analysis. • Students can explain characterization techniques for MOS devices.	E-9 Prof. Dr. Matthias Kuhl Winter Term
Mixed-signal Circuit Design Lecture, Excercise 6 ECTS 4 SWS	• Students can explain the descriptive parameters of mixed-signal systems • Students can explain various architectures of analog-to-digital and digital-to-analog converters • Students are able to explain the fundamental limitations of different analog-to-digital and digital-to-analog converters	E-9 Prof. Dr. Matthias Kuhl Winter Term

Course	Contents	Institute/Lecturer Period
Hierarchical Algorithms Lecture, Exercise 6 ECTS 4 SWS	Students are able to • name representatives of hierarchical algorithms and list their characteristics, • explain construction techniques for hierarchical algorithms, • discuss aspects regarding the efficient implementation of hierarchical algorithms.	E-10 Prof. Dr. Sabine Le Borne Winter Term
Mathematical Image Processing Lecture, Exercise 6 ECTS 4 SWS	Students are able to • characterize and compare diffusion equations • explain elementary methods of image processing • explain methods of image segmentation and registration • sketch and interrelate basic concepts of functional analysis	E-10 Prof. Dr. Marko Lindner Winter Term
Mathematics of Neural Networks Lecture, Exercise 6 ECTS 4 SWS	• Students are able to name, state and classify state-of-the-art neural networks and their corresponding mathematical basics. They can assess the difficulties of different neural networks. • Students are able to implement, understand, and, tailored to the field of application, apply neural networks.	E-10 Dr. Jens-Peter Zemke Winter Term
Numerics of Partial Differential Equations Lecture, Exercise 6 ECTS 4 SWS	• Students can classify partial differential equations according to the three basic types. • For each type, students know suitable numerical approaches. • Students know the theoretical convergence results for these approaches.	E-10 Prof. Dr. Daniel Ruprecht Winter Term
Optoelectronics II - Quantum Optics Lecture, Exercise 4 ECTS 3 SWS	Students can explain the fundamental mathematical and physical relations of quantum optical phenomena such as absorption, stimulated and spontanous emission. They can describe material properties as well as technical solutions. They can give an overview on quantum optical components in technical applications.	E-12 Prof. Dr. Manfred Eich Winter Term
Advanced System-on-Chip Design Lab 6 ECTS 3 SWS	This module provides in-depth, hands-on experience on advanced concepts of computer architecture. Using the Hardware Description Language VHDL and using reconfigurable FPGA hardware boards, students learn how to design complex computer systems (so-called systems-on-chip, SoCs), that are commonly found in the domain of embedded systems, in actual hardware. Starting with a simple processor architecture, the students	E-13 Prof. Dr. Heiko Falk Winter Term

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	learn to how realize instruction-processing of a computer processor according to the principle of pipelining. They implement different styles of cache-based memory hierarchies, examine strategies for dynamic scheduling of machine instructions and for branch prediction, and finally construct a complex MPSoC system (multi-processor system-on-chip) that consists of multiple processor cores that are connected via a shared bus.	
Real-Time Systems Lecture, Excercise 6 ECTS 4 SWS	Real-Time applications are an important class of embedded systems such as driver assistance systems in modern automobiles, medical devices, process plants and aircrafts. Their main feature is that they are required to complete work and deliver services on a timely basis. This course aims at introducing fundamental theories and concepts about real-time systems. As an introduction, the lecture describes several classes of real-time applications (e.g. digital controllers, signal processing, real-time databases and multimedia). It introduces the main characteristics of real-time systems and explains the relationship between timing requirements and functional requirements. Next, this is followed by a reference model used to characterize the main features of real-time applications. Several scheduling approaches (e.g clock-driven and priority-driven) and timing analysis techniques used for the verification and validation of the timing properties of real-time systems are introduced and discussed. The last part of the course will focus on the timing behavior of communications networks taking into account properties such as the end-to-end latency and the delay jitter, and on shared resources access control and synchronization in multiprocessor/multicore architectures.	E-13 Prof. Dr. Heiko Falk Winter Term
Soft Computing - Introduction to Machine Learning Lecture 6 ECTS, 4 SWS	Students are able to formalize, compute, and analyze belief networks, alignments of sequences, hidden Markov models, phylogenetic tree models, classical regression and clustering methods, neural networks, and fuzzy controllers. Taking part for the last time in winter 21/22	E-13 Prof. Dr. Karl-Heinz Zimmermann Winter Term
Advanced Topics in Control Lecture, Exercise 6 ECTS 4 SWS	• Students can explain the advantages and shortcomings of the classical gain scheduling approach • They can explain the representation of nonlinear systems in the form of quasi-LPV systems • They can explain how stability and performance	E-14 Prof. Dr. Herbert Werner Winter Term

Course	Contents	Institute/Lecturer Period
	conditions for LPV systems can be formulated as LMI conditions • They can explain how gridding techniques can be used to solve analysis and synthesis problems for LPV systems • They are familiar with polytopic and LFT representations of LPV systems and some of the basic synthesis techniques associated with each of these model structures • Students can explain how graph theoretic concepts are used to represent the communication topology of multiagent systems • They can explain the convergence properties of first order consensus protocols • They can explain analysis and synthesis conditions for formation control loops involving either LTI or LPV agent models • Students can explain the state space representation of spatially invariant distributed systems that are discretized according to an actuator/sensor array • They can explain (in outline) the extension of the bounded real lemma to such distributed systems and the associated synthesis conditions for distributed controllers	
Seminar Advanced Topics in Control 2 ECTS, 2 SWS	• Students can explain modern control. • Students learn to apply basic control concepts for different tasks	E-14 Prof. Dr. Herbert Werner Winter Term Summer Term
Control Systems Theory and Design Lecture, Exercise 6 ECTS 4 SWS	• Students can explain how linear dynamic systems are represented as state space models; they can interpret the system response to initial states or external excitation as trajectories in state space • They can explain the system properties controllability and observability, and their relationship to state feedback and state estimation, respectively • They can explain the significance of a minimal realisation • They can explain observer-based state feedback and how it can be used to achieve tracking and disturbance rejection • They can extend all of the above to multi-input multi-output systems • They can explain the z-transform and its relationship	E-14 Prof. Dr. Herbert Werner Winter Term

Course	Contents	Institute/Lecturer Period
	with the Laplace Transform • They can explain state space models and transfer function models of discrete-time systems • They can explain the experimental identification of ARX models of dynamic systems, and how the identification problem can be solved by solving a normal equation • They can explain how a state space model can be constructed from a discrete-time impulse response	
Control Lab A 4 ECTS, 4 SWS	• Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that can be used for controller synthesis • They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers • They are capable of representing model uncertainty, and of designing and implementing a robust controller • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain-scheduled controllers	E-14 Prof. Dr. Herbert Werner Winter Term Summer Term
Control Lab B 2 ECTS, 2 SWS	• Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that can be used for controller synthesis • They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers • They are capable of representing model uncertainty, and of designing and implementing a robust controller • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain-scheduled controllers	E-14 Prof. Dr. Herbert Werner Winter Term Summer Term

Course	Contents	Institute/Lecturer Period
Control Lab C 3 ECTS, 3 SWS	• Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that can be used for controller synthesis • They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers • They are capable of representing model uncertainty, and of designing and implementing a robust controller • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain-scheduled controllers	E-14 Prof. Dr. Herbert Werner Winter Term Summer Term
Software Security Lecture, Lab 6 ECTS 4 SWS	Taking place for the last time in winter 20/21 Students can • name the main causes for security vulnerabilities in software • explain current methods for identifying and avoiding security vulnerabilities • explain the fundamental concepts of code-based access control	E-15 Prof. Dr. Dieter Gollmann Winter Term
Intelligent Autonomous Agents and Cognitive Robotics Lecture, Exercise 6 ECTS 4 SWS	Students can explain the agent abstraction, define intelligence in terms of rational behavior, and give details about agent design (goals, utilities, environments). They can describe the main features of environments. The notion of adversarial agent cooperation can be discussed in terms of decision problems and algorithms for solving these problems. For dealing with uncertainty in real-world scenarios, students can summarize how Bayesian networks can be employed as a knowledge representation and reasoning formalism in static and dynamic settings. In addition, students can define decision making procedures in simple and sequential settings, with and with complete access to the state of the environment. In this context, students can describe techniques for solving (partially observable) Markov decision problems, and they can recall techniques for measuring the value of information. Students can identify techniques for simultaneous localization and mapping, and can explain planning	E-16 Rainer Marrone Winter Term

Course	Contents	Institute/Lecturer Period
	techniques for achieving desired states. Students can explain coordination problems and decision making in a multi-agent setting in term of different types of equilibria, social choice functions, voting protocol, and mechanism design techniques.	
Software Verification Lecture, 2 Exercises 6 ECTS 6 SWS	Students apply the major verification techniques in model checking and deductive verification. They explain in formal terms syntax and semantics of the underlying logics, and assess the expressivity of different logics as well as their limitations. They classify formal properties of software systems. They find flaws in formal arguments, arising from modeling artifacts or underspecification.	E-16 Prof. Dr. Sibylle Schupp Winter Term
Distributed Algorithms Lecture, Exercise 6 ECTS 4 SWS	• Leader Election • Colorings & Independent Sets • Tree Algorithms • Minimal Spanning Trees • Randomized Distributed Algorithms • Mutual Exclusion	E-17 Prof. Dr. Volker Turau Winter Term
EMC II: Signal Integrity and Power Supply of Electronics Systems Lecture, Exercise, Lab 6 ECTS 5 SWS	Students are able to explain the fundamental principles, inter-dependencies, and methods of signal and power integrity of electronic systems. They are able to relate signal and power integrity to the context of interference-free design of such systems, i.e. their electromagnetic compatibility. They are capable of explaining the basic behavior of signals and power supply in typical packages and interconnects. They are able to propose and describe problem solving strategies for signal and power integrity issues. They are capable of giving an overview over measurement and simulation methods for characterization of signal and power integrity in electrical engineering practice.	E-18 Prof. Dr. Christian Schuster Winter Term
Seminar on Electromagnetic Compatibility and Electrical Power Systems Seminar 2 ECTS 2 SWS	• Current research topics in the fields electromagnetic compatibility, theory of electromagnetic fields, and electrical power systems	E-6 Prof. Dr. Christian Becker E-18 Prof. Dr. Christian Schuster Summer Term Winter Term

1 SWS = 45 minutes of teaching time per week