Cologne University of Applied Science (CUAS)

Faculty of Information-, Media-, and Electrical Engineering

Module Directory

>>> Electrical and Information Engineering <<<

(currently containing roughly 85% of all available modules)

Please note that not all of the modules are offered each year.

Some general information on module availability is given in the upper right corner of the module descriptions, where two key entries are provided:

- core (**C**) vs. elective (**E**): core modules or a faculty-defined replacement will be offered each year, whereas not all of the elective module might be available.
  (Cg, Eg indicate modules only available on graduate level)
- winter (**W**) vs. summer (**S**) semester: most modules are only offered once a year, either in the winter semester (from around late September to mid February) or in the summer semester (from around mid March to early July).

Anyway, the information given in this document is meant as a first overview, and reliable information should be requested from the respective professors.

Please note that modules are taught in German language if not stated otherwise.

If a module is taught in a language other than German, this is indicated by LANG=xx in the table, with xx as language shortcut (EN: English).

Content

AD: Algorithms and Data Structures

Professor, Unit shortcut, and Unit name: Rosenthal, AD, Algorithms and Data Structures (German name: Algorithmen und Datenstrukturen)	**C - W**
Pre-requisites: Basics of object oriented programming	
Learning goals: ➢ Students will get the ability to estimate the quality of data structures and algorithms and to implement the data structures and algorithms in C++. ➢ Through laboratory sessions the safety in using of object oriented programming will be increased.	
Contents: This course will focus on data structures and algorithms for manipulating them. Data structures for storing information in tables, lists, trees, queues and stacks will be covered. Searching and sorting algorithms for these data structures will be developed and their complexity will be discussed.	

ADM: Advanced Mathematics

Professor, Unit shortcut, and Unit name: **Cg - W**
Knospe, ADM, Advanced Mathematics
(German name: Höhere Mathematik)

Pre-requisites:
MA1, MA2
Adequate knowledge of basic mathematics (calculus, linear algebra, probability theory).

Learning goals:

- The students can apply integration theory, functional analysis and vector calculus to communication systems.
- They know measure spaces and can compute integrals; in particular the Lebesgue integral in higher dimensions.
- They know the Hilbert space concept, L^2, l^2 and standard examples of Fourier analysis.
- They can integrate over curves, surfaces and solids and know the fundamental theorems of vector calculus.

Contents:

- Measures, measure spaces, discrete measures, integral on measure spaces, Lebesgue measure on R^n, Lebesgue integral, computation of multiple integrals, theorem of Fubini, change of variables
- Probability measures and spaces, random variables
- Banach spaces, linear operator, bounded operator, Hilbert spaces, general L^p and l^p spaces, orthogonal projection, orthonormal basis
- Fourier expansion in Hilbert spaces, examples l^2 and L^2[0,T], Fourier series, DFT, unitary operators, adjoint operator, Fourier transform, sampling theorem, applications
- Scalar fields, vector fields, operators grad, rot and div, curves and line integrals, gradient theorem, surfaces and surface integral, theorems of Stokes, Gauss and Green, applications

AKOM: Selected Topics on Optical Measurement

Professor, Unit shortcut, and Unit name: E - ??
(NF Gutjahr), AKO, Selected Topics on Optical Measurement
(German name: Ausgewählte Kapitel der Optischen Messtechnik)

Pre-requisites:
MA1, MA2, GO, WO, OMT
Integrals; Derivatives; trigonometric, exponential, limits; series; complex numbers; Fourier series; geometrical optics

Learning goals:

In general:
- the students learn to solve optical problems on their own

Module-specific:
- they work on little projects. students have to organize the experiment by themselves
- they will do the project management, including project draft, milestones and final presentation

Know-how/methods/learning/social competence:
- they learn to simulate the experiment with a computer
- they will split the experiment in to small portions for a better control of the different parameters
- they will use data acquisition hard- and software

Professional preparation:
- they will learn to solve a given problem and to do the time management

Contents:
- measurement of optical and non optical features using optical methods
- simulation of the problem using a computer
- data acquisition with a computer
- special aspects of geometrical optics for optical measurement
- special aspects of wave optics for optical measurement
- today's applications in optical measurement
- project management
- presentation of experimental results

ALLT: Advanced Link Layer Technologies

Professor, Unit shortcut, and Unit name: Eg - S
Böhmer (FH BRS), ALLT, Advanced Link Layer Technologies
(German name: Algorithmen und Technologien der OSI-Sicherungsschicht)

Pre-requisites:

Learning goals:
-

Contents:
- Elements of Link Layer Protocol Design
- Link Layer Algorithms
- Switch Architectures
- Multilayer Switching
- VLAN Technologies
- Link Layer Protocols (SPT, RSPT, MPLS, 802.1 q)

AM1: Applied Mathematics 1

Professor, Unit shortcut, and Unit name: Schellong, AM1, Applied Mathematics 1 (German name: Angewandte Mathematik 1)	**C - W**
Pre-requisites: MA1 and MA2. Knowledge in the following subjects: Real functions, complex numbers, derivatives, integrals, linear algebra.	
Learning goals: Acquisition of fundamental mathematical methods for information and communications engineering. The students should be able to solve differential equations and to apply the techniques of Fourier series and Fourier transformation to problems arising in information and communications engineering. The students should understand the important mathematical methods of control, signal transmission, analysis of continuous and digital signals and related problems and to be able to apply them.	
Contents: Differential equations (supplementary subjects), Fourier series, Fourier transform (Fourier integral), series of functions, complex power series. Remark: these subjects will be actually modified according to the need of advanced courses.	

AMT: Selected Sections of Measuring Technique

Professor, Unit shortcut, and Unit name: Nachtigall, AMT, Selected Sections of Measuring Technique (German name: Ausgewählte Kapitel der Messtechnik)	E - W
Pre-requisites: GE3, MA1,PH2 Wave equation, electrical and magnetical fields, differential equations, matrix calculation, fundamentals in optics, fraction law	
Learning goals: ➢ students will gather knowledge on fundamentals of the application of optical measuring methods ➢ they will learn about the construction of optical measuring systems ➢ they will be able to calculate with complex values ➢ they will know about the physical and mathematical treatment of classical optics ➢ they will know about the physical mathematical formulation about electromagnetic waves ➢ they will learn to understand the physics of laser sources and be able to calculate ➢ they will be able to calculate the beam propagation with optic components	
Contents: ➢ classical optics ➢ fraction law, beam propagation, optical components and their transmission matrixes ➢ mathematical calculation with matrixes ➢ beam splitter ➢ mirror and lenses ➢ complex curve radius ➢ Raileigh length, opening angle ➢ Cauterisation ➢ Interferrometry, holography ➢ High speed photography, smear camera records, schlieren camera records	

AN1: Analysis 1

Professor, Unit shortcut, and Unit name: Knospe, AN1, Analysis 1 (German name: Analysis 1)	**C - W**
Pre-requisites: High school mathematics	
Learning goals: To impart fundamental mathematical knowledge about Calculus.	
Contents (AN1 covers the Calculus part of the following topics): ➢ Fundamentals about sets and mappings ➢ Natural, integer, rational, real numbers, fields ➢ Divisibility, residue classes, finite fields ➢ Propositional logic ➢ Equations, inequations and their solutions ➢ Real functions and their properties ➢ Injective, surjective, bijective, inverse functions ➢ Polynomials ➢ Rational -, trigonometric -, power -, root -, exponential -, logarithmic functions ➢ Limits and continuity ➢ Differential calculus: derivative, differentiation formulas ➢ Monotony, max-min problems ➢ L'Hospital's rule ➢ Tangents, Taylor polynomials, Taylor series ➢ Newton's method ➢ Vectors and vector spaces over fields ➢ Scalar product, norm, angle, orthogonality, vector product ➢ Lines, planes ➢ Matrices, matrix operations ➢ Systems of linear equations, Gaussian elimination (over arbitrary fields)	

AN2: Analysis 2

Professor, Unit shortcut, and Unit name: **C - S**
Knospe, AN2, Analysis 2
(German name: Analysis 2)

Pre-requisites:
LA1, AN1

Learning goals:
To impart fundamental mathematical knowledge about Calculus.

Contents (AN2 covers the Calculus part of the following topics):

- Complex numbers, cartesian form, polar form
- Roots and powers of complex numbers
- Euler relationship, complex exponential

- Riemann integral
- Fundamental theorem of calculus
- Definitive and indefinitive integral
- Integration of elementary functions
- Techniques of integration
- Complex integration

- Linear differential equations with constant coefficients

- Functions of several real variables
- Partial derivatives, gradient, tangent plane

- Linear mappings (over arbitrary fields) and their matrices
- Matrices, determinants, Laplace expansion
- Cramer's rule
- Inverse matrix
- Eigenvalues and eigenvectors
- Linear (in-)dependence, basis, coordinates, dimension
- Symmetric, orthogonal matrices
- Change of basis

AO: Applied Optics

Professor, Unit shortcut, and Unit name:	C - S
Altmeyer, AO, Applied Optics (German name: Angewandte Optik)	

Pre-requisites:
MA1, MA2, PH1, PH2
Higher mathematics, basic knowledge in physics

Learning goals:
The module is thought to impart basic but important optical concepts. Additionally it is shown, that these concepts are relevant to today's optical instruments and applications. It is intended that students recognize the importance and power of the underlying concepts, so that the wish of a deeper understanding arises. The additional mandatory practical training complements the course.

Contents:

- Short Overview on today's R&D fields in Optics
- DIN sign-convention, deduction of the imaging equation in Newton and classic form, concept of principal plains, example-applications of principal plain shift: telephoto lenses and reverse telephoto lenses used in laser manufacturing
- Magnification, Angular-, axial- and loupe- magnification
- Principal planes and focal length of a two-lens system, example-application illustrating the concept: a six lens (in three groups) zoom lens
- Image brightness in dependence of the magnification, aperture, numerical aperture and effective aperture, example-application: microscope with different objective lenses
- Diffraction at a circular aperture, Airy-function, Rayleigh-criterion, resolution, beneficial magnification, example applications: microscope, lithography machine, CD / DVD pick-up optics
- One-stage and two-stage microscope, magnification, Koehler illumination
- Abbe theory of imaging, example-application: off-axis illumination in lithography

ASS: Analog Signals and Systems

Professor, Unit shortcut, and Unit name: **C - W**
Bartz / Lohner, ASS, Analog Signals and Systems
(German name: Analoge Signale und Systeme)

Pre-requisites:
MA1, MA2, GE1, GE2
Integrals; Derivatives; trigonometric, exponential, and logarithmic functions; limits; series; partial fractions expansion; complex numbers; Fourier series; R-, L-, and C-circuits

Learning goals:

In general:
- students will gather knowledge on fundamentals of analog signals and systems in theory and application

Module-specific:
- students will know about the representation of analog systems in time and frequency domain
- they will know about the concept of convolution
- they will know about the fundamentals of the Fourier transform
- they will know about the fundamentals of the Laplace transform
- they will know simple design guidelines for Butterworth and Chebyshev filters
- they will know the sampling theorem and important effects of the sampling process

Know-how/methods/learning/social competence:
- students will be able to apply the important algorithms to process analog signals in time and frequency domain: i) convolution; ii) Fourier transform; iii) Laplace transform
- they will be able to represent electrical circuits by equivalent block diagrams
- they will be able to determine the characteristics of a system in time and frequency domain, to represent them in appropriate diagrams, and to interpret them accordingly
- they will be able to determine stability of a system
- they will be able to design simple analog filters
- they will be confronted with an English language text book.

Professional preparation:
- students can build models from real world systems (preferably electrical circuits) and thereby abstract from reality
- they have learned to deal with the abstract system and to establish the relationship to the real system

Contents:
- Introduction to signals and systems
- convolution in time domain
- Fourier transform of analog signals
- correlation functions
- system representation in frequency domain; frequency response
- Laplace transform; transfer function; stability of a system
- analog filter Butterworth, Chebyshev
- sampling of analog signals

AT: Theory of Imaging

Professor, Unit shortcut, and Unit name: Altmeyer, AT, Theory of Imaging (German name: Abbildungstheorie)	**C - W**
Pre-requisites: MA1, MA2, PH1, PH2, OT1, OT2 Higher mathematics, basic knowledge in physics, beam optics and wave optics	
Learning goals: The module covers the theory of imaging. On the one hand side the cohesions in imaging are described at a high level of abstraction, giving a powerful and complete toolkit for the design and characterization of any imaging system. On the other hand some simple examples are given, where the use of the formalism is not too exhausting, but its functionality can be seen. Additionally some general considerations on optical system design are made.	
Contents: ➢ Recapitulation of the beam- and wave front concept and the imaging equations. ➢ Recapitulation of the concepts of spatial and temporal coherence. ➢ Incoherent imaging and coherence within the Airy-limit. ➢ Point Spread Function (PSF). ➢ Wave Front Aberration Function (WFAF). ➢ Optical Transfer Function (OTF) and its components, the Modulation Transfer Function (MTF) and the Phase Transfer Function (PTF). ➢ Point Spread Function (PSF) as Fourier transform of the Optical Transfer Function (OTF). ➢ Amplitude distribution of the Point Spread Function (PSF) as the Fourier Transform of the Wave Front Aberration Function (WFAF). ➢ Modulation Transfer Function (MTF) for coherent and incoherent imaging.	

AVC: Audio and Video Coding Technologies and their Applications

Professor, Unit shortcut, and Unit name: **Eg - W**

Pörschmann / Silverberg, AVC, Audio and Video Coding Technologies and their Applications
(German name: Audio- und Videocodierung und deren Anwendungen)

Pre-requisites:

Integrals; derivatives; trigonometric, exponential and logarithmic functions; limits; series; partial fractions expansion; complex numbers; Fourier series; R-, L-, and C-circuits; fundamentals in system theory and communication theory

Learning goals:

Module-specific:

- Fundamental knowledge of audio and video source coding algorithms and their applications in state-of-the-art communication systems.
- The interaction of audio and video system aspects will be commonly explained as complete systems.

Know-how/methods/learning/social competence:

- Understand and be able apply the models of audio and video embedded in coding.
- Analyse relevant criteria for the coding technologies in different applications

Professional preparation:

- Know-how in the principles of audio and video coding is required in a wide area of applications, e.g. IP-telephony / IP-videophony.
- Further applications are in the field of the development, the operation and the analysis of the Quality of Service of mobile communication systems.

Contents:

Digital Video Formats:

- Relevance and irrelevance reduction; Entropy coding; DPCM; Transformation coding

JPEG- and MPEG-Standards:

- DCT; zick-zack-scan; Macro blocks; Hybrid coding

DVB- and DMB/DXB-Standards:

- System architecture; Additional Data; Multiplexing; Channel Coding; Services and Profiles

Receiver architectures:

- Architectures for DVB-devices; Architectures for mobile devices; Broadcast-networks; HDTV; IPTV

Sound perception and production:

- Principles of human auditory perception

Speech coding:

- Principles of Speech Coding; Development of speech Coders;
- Examples of actual Speech coders (e.g. GSM-FR, WB-AMR)
- Evaluation of audio coding technologies based on the Quality of Transmitted Speech

Music coding:

- Methods of perception-based music coding (e.g. MP3)
- Methods of spatial coding (e.g. Dolby Surround)
- Concepts for the analysis and synthesis of auditory scenes

Concepts for improvements of audio quality:

- Noise reduction; Automatic Gain Control (AGC); Echo Canceller; Source separation

Audio-visual interaction

AZ1: Flat Panel Display Technique 1

Professor, Unit shortcut, and Unit name: E - **W**
Schwedes, AZ1, Flat Panel Display Technique 1
(German name: Anzeigetechnik 1)

Pre-requisites:
Mechanics, Electromagnetism, Electrical Components, Material Science, Optics

Learning goals:
Learning the fundamental principles of a flat panel display and the interaction with the human eye:

- the Human Eye, Color
- Parameters of Displays (radiometric, photometric)
- Principal of operation:
  - Addressing (finding the way to the pixel)
  - Excitation (delivering energy to the pixel)
  - Electrooptical Effect (conversion of the supplied energy into light)
- Self Emitter (active), Ambient Light Modulator (passive)
- Comparison of the Different Types of Addressing, Excitation, Electrooptical Effects (advantages, disadvantages)

Contents:
Structures of a Display, Working Principle
Optical Metrology: Radiometry, Photometry, the Human Eye (spatial and temporal resolution), Luminance, Color
Display Characteristics: Resolution, Switching Time, el.op. Characteristic Curve, el.op. Efficacy, Contrast, Viewing Characteristic, Memory Effect, Data Flow
Display Market, Fields of Application
Types of Addressing: direct, matrix, self scan (shift), grid, scan (CRT), number of drivers
Active Addressing: MIM-diode, TFT (manufacture, electrical characteristics)
Types of Excitation: electrical (current or voltage controlled), magnetical, thermal, electron ray, laser, combinations of two
Electrooptical Effect: Self Emitter, Light Modulator, Electrooptical Characteristic, Light Generating Processes in Semiconductors
CRT: the voluminous competitor in comparison with the flat display

AZ2: Flat Panel Display Technique 2

Professor, Unit shortcut, and Unit name: Schwedes, AZ2, Flat Panel Display Technique 2 (German name: Anzeigetechnik 2) Eg - ??
Pre-requisites: Flat Panel Display Technique 1 Mechanics, Electromagnetism, Electrical Components, Material Science, Optics
Learning goals: Learning the fundamental principles of specific, up to date flat panel display techniques: Each student has to give a lecture (main subject: LCD) and learns thereby to present within 15 minutes an actual technical problem
Contents: The up to date flat panel display techniques are presented (physical process of light production, manufacture, electrical and optical characteristics): ➢ Electroluminescence (EL)(ac, dc, thin film, powder), LED ➢ Plasma (PDP) (ac, dc, self scan-addressing, storage characteristic) ➢ Vacuum Fluorescence (VFD) ➢ Field Emitting Display (FED) ➢ Organic Light Emitting Diode (OLED) ➢ Liquid Cristal Displays (LCD): Twisted Nematic, Supertwisted, Guest Host, Ferroelectric, LCoS, Techniques with improved Viewing Characteristics, Bistability ➢ Electronic Paper ➢ Touch Screen Techniques

BEM: Energy Systems

Professor, Unit shortcut, and Unit name: Eg - **S**

Schellong, BEM, Energy Systems
(German name: Betriebliche Energiemanagementsysteme und Energiecontrolling)

Pre-requisites:

MA1, MA2, GE1, GE2, IN1, IN2, WRE
differential and integral calculus, algorithms, basics in software engineering, heat and power generation and distribution, objectives and methods of computer aided energy management

Learning goals:

In general:

- students will gather knowledge on energy management methods in the field of energy systems of industrial enterprises as well as of facilities and municipalities

Module-specific:

- students will know about the mathematical tools of modelling and optimizing energy systems
- they will know about the necessary informational technologies for energy data analysis
- they will know about the objectives and structure of energy management systems in industrial enterprises and in facilities
- they will learn how to analyze the energy consumption in dependence of production, climate, and facility
- they will learn how to find optimization potentials
- they will know about methods for improving the energy efficiency
- they will know tools for reducing the energy costs

Know-how/methods/learning/social competence:

- students will be able to apply the mathematical and informational tools for modelling and optimizing energy systems
- they will be able to apply suitable technologies for the reduction of energy consumption
- they will learn the interdisciplinary character of applied project work in the field energy and environmental management
- they will learn how to build up a “virtual consulting company” and to work in a project team
- they will be able to represent their results by computer aided presentations

Professional preparation:

- students can work on actual problems in the fields of energy economy, facility management, energy controlling, and portfolio management
- they have learned to apply combined methods for analyzing and optimizing industrial energy systems

Contents:

- structure of energy supply and purchase in liberalized markets
- objectives and structure of energy management systems in industrial enterprises and in facilities
- energy data analysis and energy balances
- objectives and methods of energy controlling
- energy efficiency and optimization potentials
- technologies for reducing energy consumption and their economical evaluation
- portfolio management
- energy supply concepts
- project management

BKM: Calculation and Construction of Electrical Machines

Professor, Unit shortcut, and Unit name: Brämer / Meckbach, BKM, Calculation and Construction of Electrical Machines (German name: Ber. u. Konstr. v. el. Masch.)	E - **W**
Pre-requisites: Fundamentals of electrical machines	
Learning goals: In general: ➢ Detailed knowledge on construction and calculation of Electrical Machines	
Contents: ➢ Special features on construction and calculation of electrical machines ➢ Windings ➢ Reactances ➢ Commutator effects ➢ Static converter effects	

BM: Biomedical Engineering

Professor, Unit shortcut, and Unit name: Reidenbach, BM, Biomedical Engineering (German name: Biomedizinische Technik)	**?? - ??**

Pre-requisites:
Physics; fundamentals in electrical engineering
Assumed matters: Fundamentals in electrical engineering

Learning goals:

In general and module-specific:
- The module presents the basics in biomedical engineering and technology.

Know-how/methods/learning/social competence:
- Fundamentals in general physiology and the basics in biomedical engineering are presented. The main topics belong to electrical and optical physiology.
- Actual topics from the biomedical field are treated by the students in a seminar and discussed in the respective working group.

Professional preparation:
- The students become familiar with the most important topics in biomedical engineering and technology. They will be able to understand the characteristics of electrical and optical methods, which are used in modern diagnostics
- The presentation of topics in a seminar and the supplementary discussion improves the know-how and the soft skills simultaneously.

Contents:
- Characteristics in biomedical technology as a specific field,
- Fundamentals in physiology,
- Biomedical tissue, organs,
- Electrical physiology, neurophysiology,
- Optical physiology,
- Fundamentals in diagnostic methods and measurements,
- Examples in biomedical metrology and instrumentation: electrocardiography and electroencephalography

BO: Optical Elements

Professor, Unit shortcut, and Unit name: **E - W**
Altmeyer, BO, Optical Elements
(German name: Bauelemente der Optik)

Pre-requisites:
Mathematics 1&2, Physics 1&2, Optics 1&2, Applied Optics
Higher mathematics, basic knowledge in physics, beam optics and wave optics

Learning goals:

In general:
- Physical background on electromagnetic radiation

Know-how/methods/learning/social competence:
- Physical background of generation and detection of electromagnetic radiation. Broad application of basic physical laws on several natural and technical optical systems.

Professional preparation:
- Recognition of preseverative physical principles in different contexts. Reduction of technical relevant situations to basic physical laws.

Contents:
- Generation, detection and use of electromagnetic waves in the whole spectral range, Validity of optical laws on all scales of size, focus on x-rays: physics of x-ray generation, x-ray tubes, femtosecond lasers as x-ray sources.
- Radiometry:
  energy, flux, radiant intensity, radiance, irradiance, emittance, irradiation, spherical emitter and Lambert emitter.
- Laws of radiation:
  black body radiation, Boltzmann distribution, harmonic oscillators from the classical and quantum point of view, Planck's law, Wien's law and Rayleigh-Jeans's law, Wien's shifting-law, Stefan-Boltzmann's law, Kirchhoff's law
- The human eye:
  Physiology of the eye, technical description of the eye, model of Helmholtz and Laurance, accommodation, adaption, resolution, ametropia, correction of ametropia with glasses and laser surgery: radial ceratotomie, photorefractive ceratectomie, konventional laser in-situ ceratomileusis, femtosecond-laser in-situ ceratomileusis, measurement of abberations, Shack-Hartmann sensor, wavefront-aberrometer, Zernicke-polynomials, optical illusions
- Photometry:
  spectral sensitivity of the eye, mathematical transition from radiometry to photometry, quantity of light, luminous flux, luminous intensity, luminance, illumination, exposure, light efficiency, visual efficiency.
- incadescent lamps:
  light efficiency, life time, inert gas infill, Langmuir's law, coil and double-coil, halogen gas infill, halogen cycle, bulb blackening, coil regeneration, characteristics of high- and low-voltage systems, infrared coatings, dielectric multi-layer systems.

BVS1: Operating Systems and Distributed Systems 1

Professor, Unit shortcut, and Unit name: **C - W**
Vogt, BVS1: Operating Systems and Distributed Systems 1
(German name: Betriebssysteme und verteilte Systeme 1)

Pre-requisites:
Practical Informatics: Programming in Java (or C). Basic knowledge of the architecture, operation principles and services of a von Neumann computer.

Learning goals:
- Know architectural concepts of operating systems and concurrent local and distributed systems.
- Utilize services offered by their user and system (programming) interfaces.
- Learn about the fundamental principles of concurrency, data communication and cooperation.

Contents:
- Fundamental goals, services, and implementation principles of operating systems and distributed systems.
- Introduction to UNIX.
- Concurrency and synchronization.
- Data communication in local and distributed systems.
- Client-server cooperation.

All concepts are first introduced in general terms and then illustrated by their implementations in UNIX, Java and/or the Internet.

BVS2: Operating Systems and Distributed Systems 2

Professor, Unit shortcut, and Unit name: **E - S**
Vogt, BVS2, Operating Systems and Distributed Systems 2 LANG=EN
(German name: Betriebssysteme und verteilte Systeme 2)

Pre-requisites:
Practical Informatics: Programming in Java (or C). Basic knowledge of the architecture, operating principle and services of a digital computer.
Operating Systems and Distributed Systems 1.

Learning goals:
- Learn about architectural concepts of operating systems and concurrent local and distributed systems.
- Utilize services offered by their user and system (programming) interfaces.
- Know about implementation techniques for concurrency, data communication and cooperation.

Contents:
- Object-oriented and WWW-based techniques for the implementation of distributed applications.
- Operating system support for local and distributed concurrent systems.
- Local and distributed file systems.
- Security in local and distributed systems.

All concepts are first introduced in general terms and then illustrated by their implementations in UNIX, Java and/or the Internet.

BWA: Economical Aspects for Engineers

Professor, Unit shortcut, and Unit name: **C - W,S**
Thieling, BWA, Economical Aspects for Engineers
(German name: Betriebswirtschaftliche Aspekte für Ingenieure)

Pre-requisites:

Learning goals:
- Students have knowledge of the key areas of micro-economics and are thus able to understand the non-technical processes in a company.
- Students are familiar as to how key organizational processes are executed in companies and possess the knowledge required for analysing and enhancing business processes in a company.
- They know the basic principles of accounting and their practical application.
- The students know the various modes of cost and performance calculation, their application and interpretation. They are thoroughly familiar with the basic techniques of problem analysis, planning and control, as well as forecasting and have also applied this knowledge in practical exercises.
- The students have knowledge of project management, in particular for project planning and control.

Contents:
Introduction
- The aims and purpose of a company.
- The company in its business environment.
- The internal organisation of a company (functionally structured organisation; business sector organisation; matrix organization; profit centre)

Basic terminology of accounting
- payments-in, payments-out; inputs, outputs;
- income, outgo;
- performances, costs;
- depreciation and amortisation of fixed assets

Cost and performance calculation
- absorption costing (cost categories, cost centres, cost units, machine-hour rate, internal transfer prices);
- direct costing (contribution accounting, break-even analysis, relative direct costs);
- target costing

Basic management functions
- planning (strategic planning, business plan, budgeting),
- planning (management techniques and leadership management);
- control and controlling

Project management
- project, duties and responsibilities of a project manager, project risks, flow and follow-up chart,
- costs projection, project controlling,
- critical path analysis (structural and time analysis, capacity planning, cost planning),
- management development strategies

Marketing
- sales marketing, strategic marketing,
- requirements specification as “teamwork” between marketing and development

Processes and process optimisation
- methods of process analysis, process improvement and its controlling

Basic management techniques
- methods for analysing, forecasting and scenarios, brainstorming, pareto principle, Murphy’s law

Negotiation and presentation
- formal and informal discussions / meetings,
- accomplishment and management of a conversation,
- composition and construction of a speech, graphic design, techniques of speech

CI: Computational Intelligence

Professor, Unit shortcut, and Unit name: Bartz, CI, Computational Intelligence (German name: Computational Intelligence)	Eg - **S**
Pre-requisites: Advanced mathematical skills.	
Learning goals: ➢ Students will learn to apply modern approaches and implement intelligent algorithms to specific problems. ➢ Students will understand the goals of optimization processes. ➢ Students will understand the principles of neural networks and be able to apply them to typical problems. ➢ Students will understand fuzzy technology and be able to apply it to typical problems. ➢ Students will understand the principles of evolutionary algorithms and be able to apply it to typical problems.	
Contents: ➢ **Classical optimization** strategies: objective function; constraints; multidimensional, multimodal, multiobjective optimization; LP problems and the simplex algorithm; Pareto front and Pareto set. ➢ **Neural networks**: biological archetype; neurons, net-, activation-, output-function; topologies of neural nets; training using the backpropagation-algorithm. ➢ **Fuzzy logic**: fuzzy set, membership functions; fuzzification; fuzzy inference algorithms; defuzzification methods. ➢ **Evolutionary algorithms**: fitness, genotype, phenotype; coding the genotype; selection procedures; recombination/crossover algorithms; mutation operators	

CM: Chemistry for Microelectronics

Professor, Unit shortcut, and Unit name: E - **W**
Löbach, CM, Chemistry for Microelectronics
(German name: Chemie für Mikroelektronik 1)

Pre-requisites:
Material science and Chemistry I
The periodic system of elements, theory of valence, ionic bonds and atomic bonds, the definition of acids and bases, important inorganic and organic acids and bases, important polymers

Learning goals:
In general:
- students will gather knowledge on chemicals used in making microelectronic devices and used in the field of the semiconducting industry

Module-specific:
- students will know about the difference of a positive and a negative working photoresist
- they will know about the concept of crosslinking a polymer coating with light
- they will know about dissolving unexposed polymer coatings with organic solvents
- they will know about the main components containing a negative working photoresist
- they will know about the main components containing a positive working photoresist
- they will be confronted with English language product informations

Know-how/methods/learning/social competence:
- students will be able to compare the products of different suppliers of chemicals for microelectronic industry
- they will be able to select solvents which are suitable to process exposed coated wafers and are not harmful to the laboratory stuff
- they will be able to select photoresists which are designed for different resolutions and exposure wavelengths
- they will be able to select between processes which cause much waste

Professional preparation:
- students can build models of the different light sensitive molecules that are used in preparing a photoresist
- they have learned to deal with molecule models and to prepare a photoresist solution, which is typical as a negative or a positive working phototresist

Contents:
- Diazonaphtochinon-Photoresists
- Diazido-cyclorubber-Photoresists
- Methylmethacrylat-Photoresists
- Organic solvents for the making of photoresist solutions and the processing of the exposed photoresists
- Etching techniques

DB: Relational Database Systems

Professor, Unit shortcut, and Unit name: Büchel, DB, Relational Database Systems (German name: Datenbanken)	**C - W**
Pre-requisites: basics in computer science, experience in a programming language (C++ or JAVA), knowledge of operating systems	
Learning goals: In general: ➢ Providing knowledge in the concepts of database systems, in methods of design and of implementation of database systems.	
Contents: ➢ a general model of a database system ➢ general concepts of database systems (persistent objects, storage management, data dictionary, conditions of integrity, transactions, recovery, etc.) ➢ hierarchical and network oriented database systems ➢ relational database system and SQL ➢ interfaces from programming languages (C, JAVA) to relational databases (JDBC, ESQL/C) ➢ software engineering of database systems (specification and design)	

DB1: Database Systems 1

Professor, Unit shortcut, and Unit name: Büchel, DB1, Database Systems 1 (German name: Datenbanken 1)	**?? - W**
Pre-requisites: basics in computer science, experience in a programming language (C++ or JAVA), knowledge of operating systems	
Learning goals: In general: ➢ Providing knowledge in the concepts of database systems, in methods of design and of implementation of database systems.	
Contents: ➢ a general model of a database system ➢ general concepts of database systems (persistent objects, storage management, data dictionary, conditions of integrity, transactions, recovery, etc.) ➢ hierarchical and network oriented database systems ➢ relational database system and SQL ➢ interfaces from programming languages (C, JAVA) to relational databases (JDBC, ESQL/C) ➢ software engineering of database systems (specification and design)	

DB2: Database Systems 2

Professor, Unit shortcut, and Unit name: Büchel, DB2, Database Systems 2 (German name: Datenbanken 2)	**?? - S**
Pre-requisites: basics in computer science, experience in a programming language (C++ or JAVA), knowledge of operation systems	
Learning goals: In general: ➢ Providing knowledge in the concepts of database systems, in methods of design and of implementation of database systems.	
Contents: ➢ concepts of object oriented database systems ➢ abstract data types (ADT) ➢ implementation of object oriented databases ➢ concepts of storage management and data organisation: ISAM, B-tree ➢ [an optional outlook: database systems and XML] ➢ [an optional outlook: database systems in AI]	

DBW: Database and Knowledge Representation

Professor, Unit shortcut, and Unit name: Büchel, DBW, Database and Knowledge Representation (German name: Datenbanken und Wissensrepräsentation)	Eg - **S**
Pre-requisites: basics in computer science, experience in a programming language (C++ or JAVA), knowledge of operation systems, experience in database systems (SQL, RDBS, JDBC/ODBC).	
Learning goals: In general: ➢ Providing knowledge in the concepts of knowledge representation and in techniques of concepts of knowledge representation.	
Contents: ➢ concepts of knowledge representation as a part of artificial intelligence ➢ special concepts of concepts of knowledge representation in the W3C-Stack (XML, RDF, ontologies (OWL)) ➢ structured storage organization for knowledge representation ➢ abstract data types (ADT), object-relational data modelling ➢ implementation of concepts of knowledge representation with database systems ➢ applications of knowledge based systems in natural language processing	

DBX: Database Systems and XML

Professor, Unit shortcut, and Unit name: **?? - S**
Büchel, DBX, Database Systems and XML
(German name: Datenbanken und XML)

Pre-requisites:
basics in computer science, experience in a programming language (C++ or JAVA), knowledge of operation systems, knowledge of relational database systems (architecture of RDBS, SQL, JDBC, design of RDBS with ERD and normal forms).

Learning goals:
In general:
- Providing knowledge in the concepts of database systems, in methods of design and of implementation of database systems. Providing knowledge in XML and in information interchange between database systems and XML file system.

Contents:
- XML and DTD
- Abstract data types (ADT)
- XML toolbox of a RDBMS
- Mapping XML structures on relational structures
- Implementation of object-relational databases with XML interfaces
- Native XML database systems
- Concepts of storage management and data organisation: ISAM, B-tree

DC: Digital Communications

Professor, Unit shortcut, and Unit name: **Cg - W**
Dettmar / Elders-Boll, DC, Digital Communications
(German name: Digitale Kommunikation)

Pre-requisites:
Advanced Mathematics, basics in digital communications

Learning goals:

In general:
- to gain knowledge about principles in digital communication
- to learn about fundamental mathematical methods and principles to describe transmission of digital data

Module-specific:
- to learn about signal and systems in digital communications
- to understand actual principles of digital communications
- to learn about practical transmitter and receiver structures
- to learn about techniques to increase the transmission rate and performance of digital systems

Know-how/methods/learning/social competence:
- they will be able to understand temporary systems in digital communications
- they will train their algorithmic thinking
- they will be able to determine achievable data rates
- they will be confronted with English language text books.

Professional preparation:
- students know basics on digital communication systems
- they learn basics on algorithms and their implementation

Contents:
- signals and systems for digital communication
- random variables and stochastical processes
- digital modulation and demodulation
- broad band systems
- Multiple Input Multiple Output (MIMO) Systems

DFS1: Digital TV Systems 1

Professor, Unit shortcut, and Unit name: Silverberg, DFS 1, Digital TV Systems 1 (German name: Digitale Fernsehsysteme 1)	**E - W**
Pre-requisites: MA1, MA2, GE1, GE2, ASS, DSS, MT Integrals; derivatives; trigonometric, exponential and logarithmic functions; limits; series; partial fractions expansion; complex numbers; Fourier series and transformation; R-, L-, and C-circuits	
Learning goals: Students will gather knowledge in fundamentals on statistical data processing and its applications in Digital Video Broadcasting (DVB) as well as methods for picture quality enhancements.	
Contents: ➢ Multi-dimensional picture scanning and processing ➢ Correlation techniques for picture quality improvements ➢ Noise reduction ➢ Scan rate conversion ➢ Video compression (MPEG 2/4) ➢ The DVB System (Part 1)	

DFS2: Digital TV Systems 2

Professor, Unit shortcut, and Unit name: Silverberg, DFS2, Digital TV Systems 2 (German name: Digitale Fernsehsysteme 2)	**Eg - S**
Pre-requisites: MA1, MA2, GE1, GE2, ASS, DSS, MT Integrals; derivatives; trigonometric, exponential and logarithmic functions; limits; series; partial fractions expansion; complex numbers; Fourier series and transformation; R-, L-, and C-circuits	
Learning goals: Students will gather knowledge in fundamentals on statistical data processing and its applications in Digital Video Broadcasting (DVB) as well as methods for system quality enhancements.	
Contents: ➢ The DVB system (Part 2) ➢ Channel modulation algorithms for DVB ➢ Forward error correction (FEC) ➢ Antenna diversity techniques	

DGL: Ordinary and Partial Differential Equations

Professor, Unit shortcut, and Unit name: **Cg - W**
Gornik, DGL, Ordinary and Partial Differential Equations
(German name: Gewöhnliche und Partielle Differentialgleichungen)

Pre-requisites:
MA1, MA2, LA1, LA2, PH1, PH2

Learning goals:

In general:
- Students will get across with advanced mathematical methods in electrical engineering

Module-specific:
- Students will know methods of advanced treatment of ordinarily differential equations
- They will know methods of solving of differential equation systems
- They will know methods of solving of partial differential equations (basics)

Know-how/methods learning/social competence:
- Students will able to formulate and solve problems in engineering science by differential equations

Professional preparation:
- Technical and scientific work using mathematical tools

Contents:
- Ordinary Differential Equations (advanced treatment)
- Differential Equation Systems
- Partial Differential Equations (first and second order) - basic principles

DIST: Thick Film Technology

Professor, Unit shortcut, and Unit name: E - S
Brunner, DIST, Thick Film Technology
(German name: Dickschichttechnik)

Pre-requisites:
PH1, EL1, EL2
Electronic circuits calculation of resistors, characteristics of metals and dielectrics

Learning goals:

In general:
- fundamental technological and theoretical knowledge of structure, function mode and production of thick-film hybrid integrated circuits

Contents:
- Structure of a thick-film circuit,
- characteristics of the individual layers such as conductive layer, resistivity layers, insulator layers,
- calculation of thick-film resistances,
- layout of a thick-film circuit,
- function oft he screen-printer,
- drying and burning of the thick-film circuit,
- trims of resistance,
- bonding of IC `s

DMC: Digital Motion Control

Professor, Unit shortcut, and Unit name: Eg - **W**
Krah, DMC, Digital Motion Control
(German name: Digital Motion Control)

Pre-requisites:
MA1, MA2, GE1, GE2, ASS, DSS, RT
Integrals; derivatives; trigonometric-, exponential-, and logarithmic functions; limits; partial fractions expansion; complex numbers; Fourier series and transformation; R-, L-, and C-circuits; solving of differential equations, basic of control system technology, z-transform

Learning goals:
- Sampled data control systems
- Conversion of real systems in difference equations
- Basic digital controller schemes, advantages/disadvantages: tradeoffs
- Representation of systems by equivalent block diagrams
- Fundamentals of the z-transform of systems
- Fundamentals of Digital Signal Processing, fixed point arithmetic
- Identification of the characteristics of a system in time and frequency domain, their representation in appropriate diagrams and the appropriate interpretation
- Determine stability of a closed loop discrete system
- Advanced direct digital motion control

Contents:
- Introduction to direct control system technology
- Steady state behavior of a system / plant
- z-Transform
- Sample & Hold
- Dynamic behavior
- Digital Filter
- Basic controller schemes, P, I, PI, PD and PID
- Direct Digital Control (DDC)
- Closed loop stability
- Digital motion control, torque, velocity and position control
- Feed forward and field busses
- Smith Predictor
- Luenberger Observer
- Load decoupling - anti resonance filter
- Plant identification in the frequency domain within noisy environments

DMV: Digital Modulation

Professor, Unit shortcut, and Unit name: Dettmar, DMV, Digital Modulation (German name: Digitale Modulationsverfahren)	**C - S**
Pre-requisites: ➢ UET1 (fundamentals, random signals, Baseband Transmission, Matched Filter, Nyquist criteria) ➢ Signals and Systems 1(linear systems, impulse response and transmission function, Fourier transform)	
Learning goals: General: ➢ to gain knowledge about principles in digital communications ➢ to gain experience with the application and testing of the corresponding procedures and algorithms Module-specific: ➢ to increase the knowledge of digital modulation, including bandpass systems ➢ to gain knowledge of the signal space concepts and the representation with orthogonal basis functions ➢ Line Coding ➢ to learn about the generation and reception of bandpass signals (ASK, PSK, QAM, and FSK), concepts for transmitters and receivers ➢ to learn about the effects of transmit channels as noise, fading, attenuation, interference and how to model those channels ➢ to understand OFDM as a way to cope with ISI and frequency selective channels	
Contents: ➢ System model of a digital transmission link ➢ Line Codes ➢ Signal space ➢ Bandpass Systems ➢ Modulation and de-modulation of bandpass signals, performance for the AWGN channel ➢ Channel Modelling ➢ OFDM	

DN1: Computer Networks 1

Professor, Unit shortcut, and Unit name: Grebe, DN1, Computer Networks 1 (German name: Datennetze 1) E - **W**
Pre-requisites: Boole's Algebra, fundamental knowledge in design and operation of computers and operating systems, experiences in OS (Linux preferred), programming skills (C, C++, or Java)
Learning goals: In general & Module-specific: ➢ Fundamental understanding of networking concepts, layered network models and protocols ➢ Knowledge on network elements and functions, especially the functionality of NIC, Hub, Switch, Router and Application Server. ➢ Knowledge on major standardisation organisation and processes including accessibility of standards on computer networks (IEEE standards), the TCP/IP protocol family (IETF RFC), telecommunications (ITU-T, ETSI) and mobile networks (3GPP). ➢ In depth knowledge of IP networking and routing, network application protocols, and LAN protocols ➢ Fundamental knowledge of information theory, and transmission technologies. Know-how/methods/learning/social competence & Professional preparation: ➢ Students will be able to design and configure IP networks including sub netting. ➢ Students will be able to perform intensive network testing and fault inspections. ➢ Students will be able to perform intensive protocol analysis including functional testing and performance analysis. ➢ Students will be able to design and setup IP networks for small and medium enterprises. ➢ Students are training their English skills with original standards and applications descriptions.
Contents: ➢ Introduction to computer networks, requirements, development of network technologies, applications, network topologies, characterisation of networks, switching technologies, connection orientation ➢ Communication models, layered model of networking tasks, protocols, ISO-OSI reference model, TCP/IP model, IEEE LAN model ➢ Application protocols, file transfer, FTP, TFTP, Terminal services (Telnet, SSH), Email services (SMTP), Web services (HTTP, HTTPS), Domain Name Service (DNS) ➢ Transport protocols, transport services and service classes, UDP (transport multiplex), TCP (assured transport service), transition state based protocol engines, TCP flow control, congestion control, TCP timing control ➢ Network layer technologies, switching services, connection orientation, addressing, internetworking, Internet Protocol, IP addressing (IPv4), routing, ARP, DHCP, routing protocols (distance vector RIP, link state OSPF), interdomain routing (BGP), IPv6 ➢ Data link layer technologies, framing, ARQ mechanisms, media access control, LAN protocols and performance, Ethernet variants, LAN bridging and switching, spanning-tree-algorithm ➢ Transmission technologies, fundamentals of information theory, transmission media, modulation, line coding, synchronisation, multiplexing, channel coding, error detection technologies, CRC, source coding

DN2: Computer Networks 2

Professor, Unit shortcut, and Unit name: E - **S**

Grebe, DN2, Computer Networks 2
(German name: Datennetze 2)

Pre-requisites:
Modules DN1 or NP (computer networks), and Boole's Algebra, fundamental knowledge in design and operation of computers and operating systems, experiences in OS (Linux preferred), programming skills (C, C++, or Java)

Learning goals:
In general & Module-specific:

- Fundamental understanding of network operations, network security and network management plus connection the LAN to the WAN
- Knowledge base extension on VLAN and WLAN technologies
- Knowledge base extension on WAN access technologies
- Knowledge on network security issues and security concepts.
- Knowledge on network management concepts.
- Knowledge on quality-of service mechanisms in IP based networks.

Know-how/methods/learning/social competence & Professional preparation:

- Students will be able to implement up-to-date VLAN, WLAN and WAN access in IP networks.
- Students will be able to design secured IP networks and configure IP network security rules
- Students will be able to perform intensive network testing and fault inspections with network security and network management.
- Students will be able to find protocol weaknesses by protocol analysis and functional testing.
- Students will be able to design appropriate QoS enabled networks to meet application requirements.
- Students will be able to design and setup security features and network management system in IP networks for small and medium enterprises.
- Students are training their English skills with original standards and applications descriptions.

Contents:

- Advanced LAN technologies, VLAN concepts, Wireless LAN (WLAN), connecting the LAN to the WAN (DSL, PPP, Frame Relay).
- Network security, network attacks and security targets, cryptographical algorithms, VLAN concepts, tunnelling protocols in layer 2 (L2TP, PPTP, L2F), tunnelling and encryption protocols (IPsec, TLS), packet filtering (ACL), firewalls, proxy gateways, virtual private networks (VPN)
- Network management, classification of network operation tasks and targets, TMS versus SNMP, MIB structures, introduction to ASN.1, SNMPv1 protocol, SNMPv2 protocol extensions, SNMPv3 concepts, network management services (ICMP, DHCP, DNS)
- Quality-of-Service, requirements in computer networks, QoS parameter, DiffServ concepts, IntServ concepts, resource reservation protocol (RSVP), QoS implementation in routers (scheduling algorithms)

DRD: Digital Receiver Design

Professor, Unit shortcut, and Unit name: Eg - **S**

Elders-Boll, DRD, Digital Receiver Design
(German name: Entwurf digitaler Empfänger)

Pre-requisites:
ADM, DC

Learning goals:
-

Contents:
Short Review of Digital Communication Fundamentals
- Digital Receiver Principles,
- Modulation and Demodulation Revisited

RF System Imperfections
- Nonlinearities, IQ imbalances, Phase Noise, Linear Distortion

Sampling
- Baseband Sampling and IF-Sampling

Optimal Synchronisation Algorithms
- ML Parameter Estimation

Carrier Recovery
- Frequency and Phase Synchronisation

Timing Recovery
- Symbol Synchronisation, Interpolation and Sample Rate Conversion

Channel Estimation and Equalization
- ML Channel Estimation, Equalization: Zero-forcing Equalization, MMSE-Equalization, Decision-Feedback Equalization, MLSE Equalization

Example Digital Receiver Design
- DS-CDMA or OFDM Receiver

DRF1: Digital Broadcasting and Television Systems 1

Professor, Unit shortcut, and Unit name: **E - W**
Silverberg, DRF1, Digital Broadcasting and Television Systems 1
(German name: Digitale Rundfunk- und Fernsehsysteme 1)

Pre-requisites:
MA1, MA2, GE1, GE2, ASS, DSS, MT
Integrals; derivatives; trigonometric, exponential and logarithmic functions; limits; series; partial fractions expansion; complex numbers; Fourier series and transformation; R-, L-, and C-circuits

Learning goals:
Students will gather knowledge in fundamentals on statistical data processing and its applications in Digital Video Broadcasting (DVB) as well as methods for picture quality enhancements.

Contents:
- Multi-dimensional picture scanning and processing
- Correlation techniques for picture quality improvements
- Noise reduction
- Scan rate conversion
- Video compression (MPEG 2/4)
- The DVB System (Part 1)

DRF2: Digital Broadcasting and Television Systems 2

Professor, Unit shortcut, and Unit name: **E - S**
Silverberg, DRF2, Digital Broadcasting and Television Systems 2
(German name: Digitale Rundfunk- und Fernsehsysteme 2)

Pre-requisites:
MA1, MA2, GE1, GE2, ASS, DSS, MT
Integrals; derivatives; trigonometric, exponential and logarithmic functions; limits; series; partial fractions expansion; complex numbers; Fourier series and transformation; R-, L-, and C-circuits

Learning goals:
Students will gather knowledge in fundamentals on statistical data processing and its applications in Digital Video Broadcasting (DVB) as well as methods for system quality enhancements.

Contents:
- The DVB system (Part 2)
- Channel modulation algorithms for DVB
- Forward error correction (FEC)
- Antenna diversity techniques

DSF: Digital Signal Processing with FPGA

Professor, Unit shortcut, and Unit name: **E - S**
Krah, DSF, Digital Signal Processing with FPGA
(German name: Digitale Signalverarbeitung mit FPGAs)

Pre-requisites:
MA1, MA2, GE1, GE2, ASS, DSS
Integrals; derivatives; trigonometric-, exponential-, and logarithmic functions; limits; partial fractions expansion; complex numbers; Fourier series and transformation; z-transform

Learning goals:
- Implementing of digital signal filtering algorithms in embedded systems
- Standard microcontroller implementation (slow MUL)
- Digital Signal Processor implementation (MAC)
- FPGA implementation (VHDL)

Contents:
- Sampled data processing systems
- Conversion of real systems in difference equations
- Basic digital filter schemes, advantages/disadvantages: tradeoffs
- Fundamentals of the z-transform of systems
- Fundamentals of digital signal processing, fixed point arithmetic
- Sample & Hold
- Dynamic behavior
- Sampling analog to digital converters
- Sigma-Delta analog to digital converter
- Sample Code in “C” and VHDL
- Resource optimization

DSS: Discrete Signals and Systems

Professor, Unit shortcut, and Unit name: **C - S**
Bartz / Lohner, DSS, Discrete Signals and Systems
(German name: Diskrete Signale und Systeme)

Pre-requisites:
ASS, MA1, MA2
Integrals; Derivatives; trigonometric, exponential, and logarithmic functions; limits; series; partial fractions expansion; complex numbers; Fourier series and transform; fundamentals of signals and systems; sampling process; principles of analog filters

Learning goals:

In general:
- students will gather knowledge on fundamentals of discrete signals and systems in theory and application

Module-specific:
- students will know about the representation of discrete systems in time and frequency domain
- they will know about the concept of discrete time convolution
- they will know about the fundamentals of the Fourier transform of discrete time signals (DTFT)
- they will know about the fundamentals of the z-transform
- they will know simple design IIR- and FIR-filters
- they will know about the method of bilinear transform
- they will know about DFT and the FFT algorithm

Know-how/methods/learning/social competence:
- students will be able to apply the important algorithms to process discrete time signals in time and frequency domain: i) convolution; ii) z-transform
- they will be able to determine the characteristics of a discrete system in time and frequency domain, to represent them in appropriate diagrams, and to interpret them accordingly
- they will be able to determine stability of a discrete system
- they will be able to design simple IIR- and FIR-filters
- they will be confronted with an English language text book.
- they will gather practical experiences in small analysis and design tasks (in teams of two students)

Professional preparation:
- students deepen their hands-on experience with classical measurement devices (oscilloscope, function generator,...)
- they gather first experiences in using professional tools (in this case MATLAB/Simulink) for signal analysis

Contents:
- Introduction to discrete time signals and systems
- Discrete time convolution in time domain
- Fourier transform of discrete time signals (DTFT)
- Correlation functions of discrete time signals
- Frequency response of discrete time signals
- z-transform; transfer function; stability of a discrete time system
- Discrete time filters and bilinear transform
- Windowing functions
- DFT and the FFT algorithm

DSS: Discrete Signals and Systems

Professor, Unit shortcut, and Unit name:	S
Elders-Boll, DSS, Discrete Signals and Systems (German name: Diskrete Signale und Systeme)	

Pre-requisites:
ASS
Fourier Transform, Laplace Transform, Convolution, Sampling Theorem

Learning goals:

In general:
- students will gather knowledge on fundamentals of discrete-time signals and systems in theory and application

Module-specific:
- students will know about the representation of discrete-time systems in time and frequency domain
- they will know the discrete convolution
- they will know the fundamentals of the discrete-time Fourier transform
- they will know the fundamentals of the z-transform
- they will know the sampling theorem and important effects of the sampling process
- they will know the effects that may arise form measuring signals with digital oscilloscopes

Know-how/methods/learning/social competence:
- students will be able to apply the important algorithms to process discrete signals in time and frequency domain: i) convolution; ii) discrete-time Fourier transform; iii) z-Transform
- they will be able to determine the characteristics of a system in time and frequency domain, to represent them in appropriate diagrams, and to interpret them accordingly
- they will be able to determine the stability of a system
- know the basics of digital signal processing

Professional preparation:
- know the reason why analog systems are replaced by digital systems in many applications
- students are familiar with MATLAB

Contents:
- Basic properties of Discrete-time Signals and Systems
- Discrete Time Linear Time-invariant Systems: Convolution, Correlation Functions
- Discrete-time Fourier Transform: Spectra of Discrete-time Signals, Transfer Function, Frequency Response
- Discrete Fourier Transform (DFT)
- z-Transform
- Basic Properties of Discrete-time Filters: Bilinear Transform, Windowing

DT: Technical Informatics

Professor, Unit shortcut, and Unit name: Thieling / Hartung, DT, Technical Informatics (German name: Digitaltechnik)	**C - W**
Pre-requisites: Basics in Mathematics	
Learning goals: In general: ➢ Fundamentals of digital computer science Module specific: ➢ Combinatorial digital circuits: Boolean algebra, codes, implementation, potential errors, ➢ Sequential circuits: state transition models, sequential circuits synthesis, implementation in digital elements and VHDL Know-how/methods/learning/social competence: ➢ Students will learn principle functions and methods to design and synthesize digital circuits. In small teams practical projects are implemented and coded in FPLA. Professional preparation: ➢ Digital circuits are used to design simple and effective control systems and are the basic components of microcomputers. Digital circuits are ubiquitous today, e.g. in control systems, communications, automation etc.	
Contents: ➢ Number systems, ➢ Boolean algebra, ➢ codes, ➢ combinatorial circuits, ➢ flip-flops & latches, ➢ register, ➢ counter, ➢ finite state machines, ➢ error handling, ➢ implementation in CMOS/NMOS, characteristics, FPLA, FPLS, ➢ design in digital circuits/gates and VHDL	

EA: Electrical Drives

Professor, Unit shortcut, and Unit name: **C - S**
(NF van der Broeck), EA, Electrical Drives
(German name: Elektrische Antriebe)

Pre-requisites:
Mathematics 1+2, Electrical Engineering 1+2, Power Electronics

Learning goals:

In general:
- The students learn the basic principles of electro-mechanic power conversion

Module-specific:
- The lecture deals with variable speed drives and their electronic supply circuits.
- The students understand the importance of variable speed drives for energy saving

Professional preparation:
- Within the lecture state of the art electrical drives from industry applications are presented

Contents:
- Elementary principles of translational and rotational motion
- Basic operation of DC motors
- DC motor drive with four-quadrant line commutated thyristor converter
- AC series motor drives with phase control
- Basic operation of 3~ induction motors
- Equations and equivalent circuits of induction motors for steady state operation
- Three phase voltage fed PWM inverter
- PWM and space vector control
- Induction motor fed by a PWM frequency inverter
- Operation variable speed drives in the field weakening range
- Basic operation of synchronous motors with permanent magnets
- Torque and speed control of synchronous motors by PWM inverters
- Switched reluctance drives

EBR: Introduction to Operating Systems and Networks

Professor, Unit shortcut, and Unit name:	C - W
Krah, EBR, Introduction to Operating Systems and Networks (German name: Einführung in Betriebssysteme und Rechnernetze)	
Pre-requisites: none	
Learning goals: ➢ Learning about computer system structures, processor, buses, memory, I/O, operating system peripherals ➢ Understanding the basic architecture of i86 (Intel/AMD) Windows computer systems ➢ Gathering basic knowledge of computer and programming environment	
Contents: PC architecture and its components: ➢ IO-Interfaces / specifications ➢ Digital logical layer, register layer Introduction into the Operating System Windows XP (2000): ➢ Process, Memory, Input/Output and File System ➢ Compiler, Interpreter, virtual machines, *.net (CLR) ➢ Programming of simple dialog oriented applications Computer network and Internet: ➢ An overview of network topology and communication on LAN, WAN and Public networks ➢ Hardware, packet transmitting (TCP/IP, UDP) ➢ Client server model ➢ Sockets	

EES: Embedded Systems Design Methodology

Professor, Unit shortcut, and Unit name: **Eg - W**
Hartung, EES, Embedded Systems Design Methodology
(German name: Entwurfsmethoden für eingebettete Systeme)

Pre-requisites:
Bachelor in computer science, computer engineering or comparable subject

Learning goals:

In general:
- The students should understand the value of design methods for the process of constructing embedded systems.

Module-specific: Students will
- get a deep insight into different design methods for embedded systems
- know important design methods used in industrial projects
- learn the value of prototyping based on an executable design description
- understand the value of using design patterns
- understand the differences between design methods for embedded software and hardware

Know-how/methods/learning/social competence: Students will
- evaluate embedded systems in the context of safety and robustness
- learn how to design embedded systems with state based methods (statecharts etc.) and Petri nets
- know design patterns widely used in the embedded world
- learn how to describe digital hardware systems based on hardware design languages and the differences between designing software and hardware
- write a short seminar paper about a subject taken from literature
- build a prototype for a small embedded system based on statecharts in a team (project work)

Contents:
1. Properties and requirements of embedded systems
2. Rapid Prototyping Methods
   - Statecharts and Statemate
   - Coloured Petri nets
3. UML
4. Design patterns for the embedded world
5. Design methods for digital hardware

EFA: Traction Systems of Railway Vehicles and Electrical Busses

Professor, Unit shortcut, and Unit name: Eg - **S**

Lohner, EFA, Electrical Traction Systems for Road and Railway Vehicles
(German name: Elektrische Fahrzeugantriebe)

Pre-requisites:

- Principles of Electrical Engineering 1 & 2,
- Power Electronics,
- Principles of Electrical Drives,
- Analog Signals and Systems,
- Control and Feedback Control Systems of Electrical Drives.

Learning goals:

In general:

- students will hear something about the specifics of vehicle traction systems (drive topology and control).

Module-specific:

- students become acquainted with different tram and bus propulsion systems.

Know-how/methods/learning/social competence:

- students will be able to chose the most suitable propulsion system for a given application.

Professional preparation:

- The module content is presented according to actual developments in the field of vehicle traction systems.

Contents:

- historical compendium of traction technology,
- railway vehicle with direct current machine,
- railway vehicle with three-phase machine,
- trolley-busses,
- special control algorithms,
- field oriented control,
- slip-/slide protection, etc.
- hybrid power trains,
- energy storage for vehicles.

EFS: Application of Electromagnetic Fields and Radiation

Professor, Unit shortcut, and Unit name: Eg - **W**

Schwedes, EFS, Application of Electromagnetic Fields and Radiation
(German name: Anwendung Elektromagnetische Felder und Strahlung)

Pre-requisities:
Bachelor Electrical Engineering

Learning goals:
Fundamentals, interaction and threshold and measurement of el.-magn. fields and radiation are understood.
Characterisation of the el.-magn. radiation by frequency, wavelength and photon energy can be given.
The interaction with material and biological tissue can be estimated

Contents:
- Low Frequency:
  separate investigation of electric and magnetic fields; specific biological interaction; threshold for exposition to el. and magn. fields
- High Frequency:
  appearance of polarisation and el.-magn. induction; electron spin resonance, nuclear spin resonance; biological effect of high frequency radiation, mobile radio
- Optical Radiation:
  - incoherent: far infrared, visible, UV radiation; fundamentals; photo biological interaction; luminescence; optical detectors; solar radiation
  - coherent: principle of laser; characteristics and applications; interaction of coherent light and matter; threshold values, protective measures
- Ionising Radiation:
  X-, α-, β-, γ-rays; fundamentals, history, ionisation, strong interaction with matter and biological tissue; Compton-/Photo-effect, radiation protection; radiation damage; threshold values; applications in medicine

EKS: Development of Complex Software Systems

Professor, Unit shortcut, and Unit name: E - **W**

Nissen, EKS, Development of Complex Software Systems
(German name: Entwicklung komplexer Software-Systeme; Entwurf komplexer SW-Systeme)

Pre-requisites:

Good programming skills
Lecture "Software Engineering"
Lecture "Methodological Fundamentals of Computer Science"

Learning goals:

In general:
- students will know about the application of patterns in software development
- students will know about how to develop solutions for complex problems in the field of software development
- students will know about the application of expressive formalisms for the specification of software

Module-specific:
- students will understand categories and description principles of patterns in software development
- they will know how to apply design patterns
- they will be able to develop and manage formal specifications of complex systems

Know-how/methods/learning/social competence:
- students will know and be able to apply typical design patterns
- they will understand and be able to apply specification languages to real world problems

Professional preparation:
- students will know design patterns widely used in industry
- they will be able to understand, structure and specify real-time applications
- they will have gathered experiences with a commercial specification tool

Contents:
- overview of available patterns in software development
- documentation and structuring principles of patterns
- widely used design patterns: structure, implementation and application
- introduction to standardized specification methods and languages for the development of distributed real-time software systems:
  - SDL (Specification and Description Language)
  - MSC (Message Sequence Charts)

EL1: Electronic 1

Professor, Unit shortcut, and Unit name: **C - W**
Brunner, EL1; Electronic 1
(German name: Elektronik 1)

Pre-requisites:
MA1, MA2, GE1, GE2, PH1
Integrals, Derivates, Electrostatics ; Kirchhoff´s loop and node law; complex calculation; characteristics of simple voltage and current sources; elementary integration and differentiation

Learning goals:
In general :
- students will gather knowledge on fundamentals of electronic devices in theory and application

Contents:
Properties and steady-state characteristics of:
- resistors, capacitors, inductances
- diodes, bipolar transistors, field effect transistors, IGBT
- thyristors, DIAC, TRIAC, unijunktion-transistor
- operational amplifier

EL1: Electronic 1

Professor, Unit shortcut, and Unit name: **C - W**
Pörschmann, EL1; Electronic 1
(German name: Elektronik 1)

Pre-requisites:
GE1, GE2, ANLA1, ANLA2
passive R,L,C-circuits, Kirchhoff law's, current, voltage, characteristics of simple voltage and current sources, R,L,C behavior in the time and frequency domain, linear equations, trigonometric functions, elementary integration and differentiation, calculation with complex numbers

Learning goals:
- Describe the properties of electronic circuits using transfer functions.
- Learn the basic technological and theoretical know-how on analogue electronic circuits and devices.
- Understand the methods to describe diodes, bipolar transistors and the basic circuits applying these devices.

Contents:
Mathematic and electronic basics:
- Analysis of analogue circuits, arithmetic with complex numbers

Transfer functions of linear circuits:
- Definition of transfer function, bode plot, ideal sources (current, voltage), source with internal resistances, ideal controlled sources

PN diode:
- Semiconductor basics, Characteristic curves, basic equation, rectifiers

Bipolar Transistors:
- characteristic curves and equations, operation point
- Linearization of field effect transistor circuits, amplifier circuits, frequency response

EL1: Electronic 1

Professor, Unit shortcut, and Unit name: **C - W**
Schneider, EL1; Electronic 1
(German name: Elektronik 1)

Pre-requisites:
Good knowledge of modules in the first and second semester, i.e:
Basics in electrical engineering 1 + 2: passive R,L,C-circuits, Kirchhoff law's, Current, Voltage, characteristics of simple voltage and current sources, R,L,C behavior in the time and frequency domain.
Mathematics 1+2 : linear equations, trigonometric functions, elementary integration and differentiation, calculation with complex numbers
Physics: electricity

Learning goals:
- Understanding of elementary analogue circuits

in detail:
- learn the characterization of circuits using the transfer function, frequency and phase response
- understand function and behavior of semiconductor elements and their basic circuits

Contents:
- Description and analysis of passive and active analogue circuits in the frequency domain
- Transfer function, bode-plot, bandwidth, corner frequency, controlled voltage and current sources
- Function of semiconductor elements, pn-diode, bipolartransistor, small signal model, elementary transistor circuits

EL2: Electronic 2

Professor, Unit shortcut, and Unit name: **C - S**
Brunner, EL2; Electronic 2
(German name: Elektronik 2)

Pre-requisites:
MA1, MA2, GE1, GE2, PH1
Integrals, Derivates, Electrostatics ; R- ,L- and C-circuits ; Kirchhoff´s loop and node law; complex calculation, characteristics of simple voltage- and current-sources, linear equations, trigonometric functions, elementary integration and differentiation , Electronic1

Learning goals:
In general :
- students will gather knowledge on fundamentals of electronic circuits in theory and application

Contents:
Properties and characteristics of:
- operational amplifier
- rectifier circuits
- amplifiers with bipolar and field effect transistors, astabel, bistabel and monostable multivibrators
- TTL and CMOS-Circuits
- stabilized voltage and current supplies

EL2: Electronic 2

Professor, Unit shortcut, and Unit name: Pörschmann, EL2; Electronic 2 (German name: Elektronik 2) **C - S**
Pre-requisites: Modules: EL1, GE1, GE2, ANLA1, ANLA2 passive R,L,C-circuits, Kirchhoff law's, current, voltage, characteristics of simple voltage and current sources, R,L,C behavior in the time and frequency domain, linear equations, trigonometric functions, elementary integration and differentiation, calculation with complex numbers
Learning goals: ➢ Describe the properties of electronic circuits using transfer functions. ➢ Learn the basic technological and theoretical know-how of analogue electronic circuits and devices. ➢ Understand the methods to describe field effect transistors, differential amplifiers, and operational amplifiers. ➢ Analyse embedded basic circuits
Contents: Field effect transistors: ➢ J-FET and MOS-FET, characteristic curves and equations, operation point ➢ Linearization of field effect transistor circuits, amplifier circuits Differential amplifier: ➢ Definitions of characteristic values, basic circuits, determination of difference amplification and ➢ Common mode rejection ratio Operational amplifier: ➢ Requirements for operational amplifiers, basic circuits, characteristic values of real operational amplifiers, linear operational amplifier circuits, non-linear operational amplifier circuits, comparator, trigger circuits Power amplifiers: ➢ Operation modes, A,B,C-mode, efficiency

EL2: Electronic 2

Professor, Unit shortcut, and Unit name: **C - S**
Schneider, EL2; Electronic 2
(German name: Elektronik 2)

Pre-requisites:
Electronic 1

Learning goals:
- Students will know how to set operating points of FET-Transistors
- they will be able to analyze the properties of FET-amplifiers
- they will know the difference between differential and common mode signals
- they will know the advantages of differential amplifiers
- they will be able to analyze standard circuits with operational amplifiers
- they will be familiar with effects of real op-amp-circuits
- they will know standard power amplifier configurations

Contents:
Field Effect Transistor:
- J-FET and MOSFET : Semiconductor model, IV-characteristics, transistor equations, operating point settings
- Small signal model of FETS with y-parameters, amplifier types and characteristics

Differential Amplifier:
- Introduction of differential signals and common mode signals, consideration of differential amplification and common mode amplification, common mode rejection, ideal and real amplifier behaviour

Operational Amplifier:
- Requirements for ideal operational amplifier, characteristics of real op-amp, standard circuits with negative feedback, circuits with nonlinear elements, circuits with positive feedback, effect of slew rate

Power Amplifier:
- Large signal consideration, Definition of different powers and their calculations for class A, B, and AB amplifier, calculation of efficiency, current limiting and short protection circuits

EM1: Electrical Machines 1

Professor, Unit shortcut, and Unit name: Brämer, EM1, Electrical Machines 1 (German name: Elektrische Maschinen 1)	**C - W**
Pre-requisites: Fundamentals of electrical engineering	
Learning goals: ➢ Fundamentals of construction, application, and operation of transformers and electrical machines	
Contents: ➢ Transformer ➢ DC -, AC-, and synchronous machines ➢ Small power motors ➢ Electrical circuit ➢ Operation characteristics	

EM2: Electrical Machines 2

Professor, Unit shortcut, and Unit name: Brämer, EM2, Electrical Machines 2 (German name: Elektrische Maschinen 2)	**?? - ??**
Pre-requisites: Fundamentals of electrical machines	
Learning goals: ➢ Knowledge on construction and operating characteristics of machines fed by converter ➢ Operation of small power machines and special applications of energy converters ➢ Measuring and evaluation of operating characteristics	
Contents: ➢ Operating characteristics of motion controlled brushless dc-motor ➢ How to find the optimum of a line operated wind-powered generator ➢ Step motor control optimization using evaluation of an encoder	

EMM: Energy Management in Networked Energy Systems

Professor, Unit shortcut, and Unit name: Eg - **W**
Stadler, EMM, Energy Management in Networked Energy Systems
(German Name: Energiemanagement in Energieverbundsystemen)

Pre-requisites:
Physics, Basics of Electrical Power Generation

Learning goals:
Networked electrical energy systems are of great complexity and sensitive structures. The known reliability of the European transmission network is only maintained by a high degree of automation. Students learn how large transmission networks are organized.

In the principal part students study the challenges of future electricity supply systems with high penetration of renewable energies. Different approaches of solutions for expected problems with those energy systems are discussed and analyzed.

Further, the demand side is discussed and how electricity demand can be optimized without restricting energy services.

Contents:
- Structure of networked electricity supply systems
- The European network UCTE
  - Electricity generation capacities
  - Control Power
  - Balance Power
  - Energy Storage
- Basics of safety technology and network control technology
- Discussion of options for future energy supply systems and their related challanges and problems
- Discussion of different methods of resolution:
  - Large area electricity transport
  - Thermal energy storage in combination with CHP and heat pumps
  - Load management, explained with examples like compressed air systems, HVAC systems and pumps
  - Demand Response
  - Compressed air storage

EMV: Electromagnetic Compatibility

Professor, Unit shortcut, and Unit name: **Cg - S**
Humpert, EMV, Electromagnetic Compatibility
(German name: Elektromagnetische Verträglichkeit)

Pre-requisites:
PH1, PH2, MA1, MA2, GE1, GE2
fundamentals in physics; advanced knowledge in electrical engineering and mathematics

Learning goals:

In general:
- students will gather knowledge on fundamentals of electromagnetic influences on electrical systems
- they will learn methods how to calculate a disturbance variable and how to reduce it

Module-specific:
- students will learn the definition of electromagnetic compatibility (EMC) and legal requirements
- they will know the different types of electromagnetic signals and the main sources of electromagnetic disturbances
- they will know the representation of different electromagnetic signals in the time and frequency domain
- they will learn the different coupling ways of electromagnetic disturbances
- they will know different methods to reduce electromagnetic disturbances by optimizing the design of electrical circuits, by filtering and by shielding

Know-how/methods/learning/social competence:
- students will be able to classify electromagnetic signals in time and frequency domain
- they will be able to apply algorithms to process disturbance signals in time and frequency domain
- they will be able to apply EMC-measures to reduce disturbances in dependence of the type and frequency of the disturbance
- they will be able to design the position and height of lightning arresters
- they will be able to calculate disturbances in the case of conductive, inductive and capacitive coupling in simple arrangements
- they will be able to calculate the thickness of shielding

Professional preparation:
- students have learned about the importance of electromagnetic compatibility and about its legal requirements
- they will be able to identify and to analyze electromagnetic problems in applications

Contents:

Fundamentals of electromagnetic compatibility
- Definition and standards
- Mathematical methods: Fourier transformation, time and frequency domain

Sources of electromagnetic disturbances
- Classification of electromagnetic signals
- Narrow band sources
- Intermittent broad band sources
- Transient broad band sources

Coupling ways and methods to prevent them
- Conductive coupling
- Inductive coupling
- Capacitive coupling
- Coupling by electromagnetic waves
- Identification of couplings ways

Passive EMC-measures
- Shielding
- Electromagnetic filter
- Surge arresters

ENE1: Renewable Energies 1

Professor, Unit shortcut, and Unit name: Stadler, ENE1, Renewable Energies 1 (German Name: Erneuerbare Energien 1) This module is held in both German and English language!	**C - W**

Pre-requisites:
Physics, Basics of Electrical Power Generation

Learning goals:
Climate change and scarcity of resources are reasons for fundamental changes in European energy supplies. Students will get an overview on various technologies for the use of renewable energies and the efficient use of energy to produce electricity and heat. Students will be enabled to plan renewable energy systems and know the potentials of those technologies. Part 2 of the lecture deals with all kinds of solar energy conversion processes and fuel cells.

Contents:

- Introduction to energy situation, need for renewable energies and energy efficient technologies
- State of the art and potentials
- Photovoltaics
  - Solar radiation
  - Photovoltaic cell, photovoltaic module
  - From module to systems, shading
  - Grid connected photovoltaic systems
  - Design and sizing of photovoltaic systems
- Stand-alone Systems for electricity supplies
  - Solar-Home-Systems
  - Batteries
  - Diesel Generators
  - Power electronic components
  - Hybrid systems
  - Typical applications
- Solar thermal steam power stations
  - Parabolic reflectors
  - Tower power stations
- Solar thermal heat generation
- Fuel cells
  - Types and systems
  - Hydrogen generation
  - Reformation
  - Hydrogen storage

ENE2: Renewable Energies 2

Professor, Unit shortcut, and Unit name: **C - S**
Stadler, ENE2, Renewable Energies 2
(German Name: Erneuerbare Energien 2)
This module is held in both German and English language!

Pre-requisites:
Physics, Basics of Electrical Power Generation

Learning goals:
Climate change and scarcity of resources are reasons for fundamental changes in European energy supplies. Students will get an overview on various technologies for the use of renewable energies and the efficient use of energy to produce electricity and heat. Students will be enabled to plan renewable energy systems and know the potentials of those technologies. Part 2 of the lecture deals with wind energy, biomass, geothermic energy and hydro power.

Contents:
- Introduction to energy situation, need for renewable energies and energy efficient technologies
- State of the art and potentials
- Wind Energy
  - Wind resources, physics of wind, aerodynamics
  - Wind measurements
  - History of wind power, types of wind turbines
  - Nacelle, power train, gear, breaks, etc.
  - Electrical Systems for wind turbines
  - Control aspects
  - Power and energy yield of wind turbines
  - Planning and operation of wind turbines
- Use of biomass
  - potentials
  - biomass conversion processes
  - technologies for the use of biomass for electricity production and heating
- hydro power, especially „micro-hydro“
- geothermal energy for electricity production and heating
  - deep geothermal energy
  - near-surface geothermal energy

ENS: Energy Storage

Professor, Unit shortcut, and Unit name: Nachtigall, ENS, Energy Storage (German name: Energiespeicher)	E - W,S

Pre-requisites:
EE1, EE2, WK
Electroanalysis, metals, oxidation, reduction, plastics and their properties, renewable resources, catalyst

Learning goals:
- students will gather knowledge on fundamentals of the application of energy storage
- they will know about the construction
- they will know about the chemical reactions
- they will understand commercial application
- they will be able to design fuel cells
- they will understand the reasons for the limited lifetime
- they know about the degree of efficiency
- they will learn about the configurations

Contents:
- energy conversion
- different methods for energy storage
- construction of different energy storage systems
- chemical processes
- operating points
- measuring on a fuel cell and changing parameters
- fuel cells
- chemical, biological and thermal methods for energy storage
- lifetime and degree of efficiency
- mechanical and pneumatical energy storage

ES: Embedded Systems

Professor, Unit shortcut, and Unit name: **E - W**
Hartung, ES, Embedded Systems
(German name: Eingebettete Systeme)

Pre-requisites:
Course in elementary computer architecture;
Programming Course (C, C++, Java)

Learning goals:

In general:
- students are introduced in embedded systems, as well in theory as in practice.

Module-specific: Students will
- see how to describe embedded systems with well-known methods
- know the differences of embedded systems to PC systems
- know the fundamental differences between a computer solution and a “hardware” solution and the chances of SOPC-architectures
- know different programming languages for embedded processing, especially Assembler and C
- deeply understand the problem of real-time processing in the embedded context
- understand distributed embedded components

Know-how/methods/learning/social competence: Students will
- describe embedded systems with Structured Analysis and UML from different views
- design and program typical software components of embedded systems under the context of
  a) mainloop-based execution
  b) synchronous execution based on Timer
  c) multitasking
- carrying out a embedded project either within a self-chosen or a given context on a SOPC board

Contents:
1. Description of embedded systems
   - Structured Analysis with Real-Time extensions, UML, Petri-Nets
2. Computer-based Embedded Systems
   - Typical architectures and SOPC
   - Assembler programming (by example)
   - Interrupts and Exceptions
   - State based programming in C (mainloop)
   - Programming with Timer and Callbacks
   - Real-Time Operating Systems: OSEK, POSIX
   - Linux and Realtime Processing; the ADEOS concept
   - Scheduling Strategies
3. Distributed embedded systems
   - Concepts and terminology
   - Message Passing systems
   - Network variable communication and LON
   - Message Objects in OSEK/VDX
   - RPC-based systems
   - Introduction to field bus

ESES: Draft and Simulation of Electronic Circuits

Professor, Unit shortcut, and Unit name: Brunner, ESES, Draft and Simulation of Electronic Circuits (German name: Entwurf und Simulation elektronischer Schaltungen)	E - W
Pre-requisites: EL1, EL2 Electronic circuits, electronic devices	
Learning goals: In general: ➢ fundamental technological and theoretical knowledge of simulation of elektronic circuits	
Contents: ➢ Introduction to the programs Pspice and Multisim, ➢ Simulation practicabilities, ➢ Simulation of smaller well-known circuits from the lectures electronic 1 and electronic 2, borders and errors of the computer simulation, ➢ Simulation of larger not well-known circuits	

EV1: Electrical Power Generation

Professor, Unit shortcut, and Unit name:	C - W
Späth, EV1, Electrical Power Generation (German name: Elektrische Energieerzeugung)	

Pre-requisites:
PH1
Physics (thermodynamics)

Learning goals:

In general:
- students will gather fundamental theoretical and technological knowledge about the generation of electrical power

Module-specific:
- see above

Know-how/methods/learning/social competence:
- students will learn the general principles of power generation
- they will learn to work in teams

Professional preparation:
- students will gather knowledge that can be applied directly in their professional life. Excursions are supporting the applied character of this module.

Contents:
- Fundamentals about thermodynamics and nuclear physics
- Steam power stations on the basis of fossil fuels
- Gas turbine stations
- Combined cycle power plants
- Steam power stations on the basic of nuclear power

EV2: Electrical Power Distribution

Professor, Unit shortcut, and Unit name: Späth, EV2, Electrical Power Distribution (German name: Elektrische Energieverteilung)	**C - S**
Pre-requisites: GE1, GE2	
Learning goals: In general: ➢ Students know the basic structure and operation of electrical power systems. They know the most important elements such as transmission lines, transformers, generators etc. and the corresponding mathematical descriptions. Module-specific: ➢ see above Know-how/methods/learning/social competence: ➢ students will learn the general principles of power distribution ➢ they will learn to work in teams Professional preparation: ➢ students will gather knowledge that can be applied directly in their professional life. Excursions are supporting the applied character of this module.	
Contents: ➢ symmetrical components ➢ line equations, calculation of the line parameters, transmission lines ➢ calculation of high-voltage networks ➢ calculation of electrical power networks for medium- and low- voltage ➢ short-circuit calculations	

EW: Energy Economics

Professor, Unit shortcut, and Unit name: E - **S**

Stadler, EW, Energy Economics
(German Name: Energiewirtschaft)

Pre-requisites:
Basics of Electrical Power Generation

Learning goals:
Students learn about coherences between the world's energy systems and their influence on environment and resource management. They will be able to assess energy flows of different primary energy sources and know about their different energy conversion processes. Students learn to know different energy related laws and agreements and know the operating mode of energy and emission markets.

Contents:
- Development of the world wide energy demand, correlation with population growth, correlation with increase of carbon dioxide concentration in air
- Development of the coverage of the world wide energy demand
- Development of the energy demand in Germany, comparison to other national economics with significantly lower and higher energy demands
- Energy system of Germany
- Emphasise the predominant meaning of thermal energy in the overall energy demand with space and process heat
- Energy conversion chain
- Basics of energy policy
- Laws and agreements, as:
  - Energy economic law „Energiewirtschaftsgesetz“
  - Association Agreement „Verbändevereinbarung“
  - Grid Code
  - Renewable Energy law
  - CHP-law
  - Energy Saving Agreement „Energieeinsparverordnung EnEV“
- Dynamic economic calculations
- Electricity trading and energy stock exchanges
- Emissions and emissions trading

FB1: Fieldbus Systems 1

Professor, Unit shortcut, and Unit name: E - **W**

Bartz, FB1, Fieldbus Systems 1
(German name: Feldbus-Grundlagen; Feldbusse und dezentrale Automatisierung 1)

Pre-requisites:

TI1, GE1
digital logic circuits; binary numbers; voltage and current; C-programming

Learning goals:

In general:

- students will gather knowledge on fundamentals communication mechanisms with special focus on the fieldbus area

Module-specific:

- students will know about the major network topologies
- they will know about the principles of the ISO/OSI model
- they will know about the tasks of the lower two layers (data link and physical) in fieldbus communication
- they will know about the most important bus access methods
- they will know about parity, checksum, and CRC algorithms
- they will know about the details of the CAN (controller area network)

Know-how/methods/learning/social competence:

- students will be able to determine benefits and drawbacks of different Layer 1 and Layer 2 solutions
- they will be able to design and implement communication solutions based on CAN
- they will have gained practical experiences in implementing CAN-based communication as well as sensor and actor access in a microcontroller environment (C167 controller, programmed in C)
- they will gather practical experiences in team-based design tasks

Professional preparation:

- students deepen their hands-on experience with embedded systems and a microcontroller (incl. symbolic debugging)
- they gather first experiences in implementing CAN-based communication
- they deepen their experiences in accessing sensors and actors in an embedded environment

Contents:

- Topologies; communication classification and fieldbus domain
- fundamentals of the ISO/OSI communication model
- major tasks of a physical layer; RS-485; Bit-coding
- major tasks of a data link layer; CRC et al.; bus access (master/slave, token, CSMA); synchronization
- details of the CAN (controller area network) specification
- practical experiences: designing and implementing C programs for a microcontroller (C167) in order to access local sensors and actors and to send and receive CAN messages

FB2: Fieldbus Systems 2

Professor, Unit shortcut, and Unit name: E - **S**

Bartz, FB2, Fieldbus Systems 2

(German name: Kommunikation in der Automatisierung; Feldbusse und dezentrale Automatisierung 2)

Pre-requisites:

FG, TI1

digital logic circuits; binary numbers; C-programming; fundamentals of ISO/OSI communication; physical layer and data link layer concepts

Learning goals:

In general:

- students will gather deeper knowledge on typical communication mechanisms with special focus on the fieldbus area and layer 7

Module-specific:

- students will know about the major network topologies
- they will know about the principles of layer 1 and 2 of the Interbus-S communication solution (ring topology, specific transmission protocol,...)
- they will know about the principles of layer 1 and 2 of the Profibus communication solution (token management; service groups; transmit/receive buffers;...)
- they will know about the most important characteristics of layer 7 solutions in the fieldbus area (objects, services, directories, access control mechanism,...)

Know-how/methods/learning/social competence:

- students will be able to determine benefits and drawbacks of different communication solutions
- they will be able to engineer communication solutions in the fieldbus area
- they will have gained experiences with topics that contain a huge amount of detail information
- they will have gained practical experiences in implementing CAN-based communication as well as sensor and actor access in a microcontroller environment (C167 controller, programmed in C)
- they will gather practical experiences in team-based design tasks

Professional preparation:

- students deepen their hands-on experience with embedded systems and a microcontroller (incl. symbolic debugging)
- they gather first experiences in implementing CAN-based communication
- they deepen their experiences in accessing sensors and actors in an embedded environment

Contents:

- Interbus-S: basics of layer 1 and layer 2
- Profibus: basics of layer 1 and layer 2
- importance and major characteristics of layer 7 in a fieldbus environment
- specific characteristics of layer 7 of the Interbus-S communication solution (similar to FMS and MMS)
- practical experiences: continued design and implementation of C programs for a microcontroller (C167) in order to access local sensors and actors and to send and receive CAN messages

FC: Photographic Chemistry

Professor, Unit shortcut, and Unit name: E - **S**
Löbach, FC, Photographic Chemistry
(German name: Fotografische Chemie)

Pre-requisites:
Acid-Base-Reactions, Redox-Reactions, electrochemistry, silver and silverhalides, organic reducing agents, organic dyes, polyesters, gelatin

Learning goals:

In general:

- students will gather fundamental knowledge on materials and processes in silver halide photography

Module-specific:

- students will learn about the manufacture and the physical properties of black and white photographic materials, color negative films and color papers and the processing of color materials (silver halides materials)
- they will know about the sensitivity of silver halide materials
- they will know about the different processing steps to produce a black and white or a color picture from the exposed materials
- they will know about the chemicals used in the processing solutions

Know-how/methods/learning/social competence:

- students will be able to apply different materials for different exposure situations
- they will be able to choose between materials with poor image quality and good image quality
- they will be able to choose between materials for consumer photography and professional photography
- they will be able to select materials with good image permance
- they will use the English language processing handbooks of the leading photographic companies

Professional preparation:

- students will be able to compare similar types of photographic materials from the leading companies

Contents:

- Black & white films, black & white papers
- Color negative films and color papers
- Color reversal films and color reversal papers
- Black & white processing
- Processing of color negative films
- Processing of color papers
- Image quality and image permanence of color materials

FG: Introduction to Fieldbus Systems

Professor, Unit shortcut, and Unit name: **E - W**
Bartz, FG, Introduction to Fieldbus Systems
(German name: Feldbus-Grundlagen; Feldbusse und dezentrale Automatisierung 1)

Pre-requisites:
TI1, GE1
digital logic circuits; binary numbers; voltage and current; C-programming

Learning goals:

In general:
- students will gather knowledge on fundamentals communication mechanisms with special focus on the fieldbus area

Module-specific:
- students will know about the major network topologies
- they will know about the principles of the ISO/OSI model
- they will know about the tasks of the lower two layers (data link and physical) in fieldbus communication
- they will know about the most important bus access methods
- they will know about parity, checksum, and CRC algorithms
- they will know about the details of the CAN (controller area network)

Know-how/methods/learning/social competence:
- students will be able to determine benefits and drawbacks of different Layer 1 and Layer 2 solutions
- they will be able to design and implement communication solutions based on CAN
- they will have gained practical experiences in implementing CAN-based communication as well as sensor and actor access in a microcontroller environment (C167 controller, programmed in C)
- they will gather practical experiences in team-based design tasks

Professional preparation:
- students deepen their hands-on experience with embedded systems and a microcontroller (incl. symbolic debugging)
- they gather first experiences in implementing CAN-based communication
- they deepen their experiences in accessing sensors and actors in an embedded environment

Contents:
- Topologies; communication classification and fieldbus domain
- fundamentals of the ISO/OSI communication model
- major tasks of a physical layer; RS-485; Bit-coding
- major tasks of a data link layer; CRC et al.; bus access (master/slave, token, CSMA); synchronization
- details of the CAN (controller area network) specification
- practical experiences: designing and implementing C programs for a microcontroller (C167) in order to access local sensors and actors and to send and receive CAN messages

FRS: Anglophone Technical Seminar

Professor, Unit shortcut, and Unit name: Welker, FRS, Anglophone Technical Seminar (German name: Englischsprachiges Fach-Seminar)	Cg - S

Pre-requisites:
GE1, GE2?
Basic command of the English language; advanced knowledge in electrical engineering and another technical subject

Learning goals:

In general:
- students will train to give a talk and to discuss in English
- they will learn/improve presentation techniques

Module-specific:
-

Know-how/methods learning/social competence:
- see above

Professional preparation:
- see above

Contents:
- selected topics of Electrical Engineering and Optical Technologies
- details are dependant on guest speakers and students' oral skills

FS: Electromagnetic Fields and Radiation

Professor, Unit shortcut, and Unit name: **?? - ??**
Reidenbach, FS, Electromagnetic Fields and Radiation
(German name: Elektromagnetische Felder und Strahlung)

Pre-requisites:
Physics; fundamentals in electrical engineering
Assumed matters: Electrical and magnetic field, fundamentals on waves, fundamentals in optics

Learning goals:

In general:
- Electromagnetic fields and high frequency currents;
- Coherent optical radiation

Module-specific:
- Application of electromagnetic fields and high frequency currents
- Coherent optical radiation (laser radiation)

Know-how/methods/learning/social competence:
- Treatment of the total electromagnetic spectrum from low frequency to high frequency up to optical radiation and ionizing radiation, especially concerning generation, application, interaction, and limit values.

Professional preparation:
- The application of electromagnetic fields and radiation has been extended to various areas in engineering and will accelerate even more.
- The potential biological interactions and the specification of limit values should be known to degree holders and have to be taken into account during the development and design of devices and products due to the existing rules and regulations.

Contents:
Electromagnetic fields and high frequency currents:
- Medical applications;
- Biological interactions of electromagnetic fields;
- Status and urgent need for research;

Coherent optical radiation (laser radiation):
- Laser principle, laser types and beam characteristics;
- Laser hazards;
- Regulations, rules and standards

FSA: Formal Languages and Automata

Professor, Unit shortcut, and Unit name: **C - S**
Nissen, FSA, Formal Languages and Automata
(German name: Formale Sprachen und Automatentheorie)

Pre-requisites:
Basics of Computer Science

Learning goals:

In general:
- students will gather knowledge and experience in working with abstract formalisms

Module-specific:
- students will know about abstract machines, their properties and computing power
- they will know about the Chomsky-hierarchy and the different types of languages and grammars
- they will know about the equivalence of grammars, languages and machine model
- they will be able to prove properties of languages
- they will be able to prove equivalence of languages, grammars and machine models
- they will be able to write programs for finite automata, pushdown automata and turing machines

Contents:
- Fundamental definitions
- Introduction to Grammars: formal definition, Chomsky-hierarchy, language of a grammar
- Regular languages: finite automata, regular expressions
- Properties of regular languages: closure properties, pumping lemma, decision algorithms
- Context-free languages: derivation tree, pumping lemma, closure properties, normal forms, pushdown automata
- Context-sensitive languages
- Type-0 languages
- Turing machines

GDT: Fundamentals of Display Technique

Professor, Unit shortcut, and Unit name: E - **W**

Schwedes, GDT, Fundamentals of Display Technique
(German name: Grundlagen der Displaytechnik)

Pre-requisities:
mechanics, electromagnetism, electrical components, material science, optics

Learning goals:
The fundamental working principle of flat panel displays and the interaction with the human eye are understood:

- the human eye, colour
- parameters of displays
- principal of operation:
  - addressing (finding the way to the pixel)
  - excitation (supplying energy to the pixel)
  - el.-opt. effect (conversion of energy into light)
- self emitter (active), ambient light modulator (passive)

Comparison of the different types of addressing, excitation, el.-opt. effect (advantage, disadvantage)

Contents:
Working principle and parameters of displays:

- addressing, excitation, el.-opt. effect
- resolution, switching time, el.-opt. curve, el.-opt. efficacy, contrast, viewing characteristic, memory effect,

Optical Metrology:

- the human eye (spatial and temporal resolution), radiometry, photometry, luminance, colour

Demands on Displays:

- high informative displays, data flow, display market, fields of application, different techniques

Types of Addressing:

- direct, matrix, self scan (shift), grid, scan (CRT), number of drivers
- active addressing: imprinting of characteristics, MIM-diode, TFT (manufacturing, electrical characteristics)

Types of Excitation:

- electrical (current or voltage controlled), magnetic, thermal, electron ray, laser

Electrooptical Effect:

- self emitter, light modulator, el.-opt. characteristic, light generating processes in semiconductors;
- the reference to actual display techniques is given: LCD, PDP and others

GE1: Principles of Electrical Engineering 1

Professor, Unit shortcut, and Unit name: **C - W**

Dederichs, GE1, Principles of Electrical Engineering 1
(German name: Grundgebiete der Elektrotechnik 1 (Ba))

Pre-requisites:
College mathematics

Learning goals:

The students know:

- important electrical quantities and units, the system of the SI – units
- concepts of work, power and efficiency
- Kirchhoff's current and voltage laws, Ohm's law, superposition theorem
- fundamental methods for analyzing electrical circuits in steady state
- concepts of electric and magnetic fields
- electronic components with linear and nonlinear characteristic
- measuring instruments and methods for electrical quantities
- transient response of circuits containing RC or LC, first order differential equations

The students are able to:

- uniquely assign quantities and units
- analyze complicated and complex electrical circuits
- calculate electric and magnetic fields, capacitances and inductances for easy configurations
- explain the mode of operation of linear and nonlinear components; calculate current and voltage in electrical networks consisting of such components
- use of ammeters and voltmeters
- distinguish steady state and transient response

Contents:

- quantities and units: voltage, current, power, work, resistance; dc, ac, rms of sinusoidal current; concept of resistance, resistances with linear characteristics
- Ohm's law, Kirchhoff's voltage and current law: series and parallel circuits, meshes, branches, polarity conventions for current and voltage
- sources, circuit analysis, concept of equivalent circuit: ideal sources, real sources, Norton's theorem, Thevenin's theorem, Y-□-transform, nodal analysis, graphical methods
- measuring instruments: voltmeter and ammeter, measuring range extension
- power, maximum power transfer theorem, impedance matching, efficiency
- electrical conductivity: metals, semiconductors, insulators, temperature dependence of resistors, temperature coefficient (linear and quadratic)
- nonlinear components: PTC and NTC resistor, load line solutions for a diode
- electric field: electric field strength, electric displacement field, permittivity, capacitor, current density, conductivity
- magnetic field: magnetic field strength, magnetic induction, permeability, Ampere's law, calculations of fields for easy configurations, magnetic circuit, magnetic materials, hysteresis, inductance and calculation of inductance, law of induction,
- transient response of RC or LC circuits
- transient response and energy

GE2: Principles of Electrical Engineering 2

Professor, Unit shortcut, and Unit name: **C - S**
Dederichs, GE2, Principles of Electrical Engineering 2
(German name: Grundgebiete der Elektrotechnik 2 (Ba))

Pre-requisites:
College Mathematics module 1
Principles of Electrical Engineering 1

Learning goals:

The students know:
- AC circuits under steady state
- instantaneous, average and RMS - values
- steady-state responses of R, L and C to sinusoidal inputs
- complex impedances and admittances, concept of duality
- power in AC circuits
- transformer
- resonance
- transfer functions

The students are able to:
- calculate average and rms-values of periodic voltages and currents
- analyze RLC circuits
- transform series circuits into parallel circuits
- reduce the reactive power in an AC circuit
- develop resonance circuits
- explain the bode diagram of RC- and LC- circuits
- understand the mode of operation of a transformer

Contents:
- periodic and non periodic quantities, AC quantities, instantaneous values of sinusoidal currents
- average and rms values of sinusoidal currents and voltages and voltages of different waveforms
- complex impedances of R, L and C, complex impedances of series and parallel circuits, dual circuits
- concept of complex power, apparent power, real power, reactive power, power factor
- improvement of the power factor, power matching in AC circuits
- parallel and series resonance, bandwidth, half power points
- transfer function of RC- and LC- low and high passes, Bode diagram
- open-circuit test and short-circuit test on transformers
- easy equivalent circuits of transformers

GE3: Principles of Electrical Engineering 3

Professor, Unit shortcut, and Unit name: Späth / Stoll, GE3, Principles of Electrical Engineering 3 (German name: Grundgebiete der Elektrotechnik 3)	**C - S**
Pre-requisites: LA1, LA2, AN1, AN2	

Learning goals:
In general:
➢ Principles of Electrical engineering necessary for the understanding of the following studies
➢ The students will get a fundamental understanding of electromagnetic Fields.
Module-specific:
➢ Basic concepts of Electrostatic, Magnetostatics, Elektrodynamics
Know-how/methods/learning/social competence:
➢ To be able:
    ➢ to understand basic concepts.
    ➢ to use the knowledge in energy and in the high-frequency technology
    ➢ to study by ones own.
    ➢ to work within a team.	

Contents: Electrostatics: Electric charge, Coulomb's law, Electric field, Gauss's law, Electric potential, Electric dipole moment Magnetostatics: Ampère's circuital law, Magnetic field, Magnetic flux, Biot-Savart law Magnetic dipole moment Electrodynamics: Electric current, Current density, Lorentz force law, Electromotive force, Electromagnetic induction, Transformator, Faraday-Lenz law, Displacement current, Maxwell's equations, Electromagnetic field, Electromagnetic radiation	

GO1: Basic Optics 1

Professor, Unit shortcut, and Unit name:	C - W
Poncar, GO, Basic Optics (German name: Grundgebiete der Optik)	
Pre-requisites: Mathematics and geometry: Integrals; Derivatives; trigonometric, exponential, and logarithmic functions; limits; complex numbers;	
Learning goals: ➢ Gauss optics: imaging by reflexion and refraction, very thin and thick lenses, objectives, principal planes, apertures, aberrations and their corrections, the human eye, optical instruments (telescopes, collimators and auto-collimators) ➢ Wave optics: description and classification of waves; interference of two waves and N waves, interferometers, diffraction; resolution of optical instruments; light polarisation	
Contents: See learning goals	

GO2: Basic Optics 2

Professor, Unit shortcut, and Unit name:	C - ?
Poncar, GO1, Basic Optics 1 (German name: Grundgebiete der Optik 1)	
Pre-requisites: Mathematics and geometry: Integrals; Derivatives; trigonometric, exponential, and logarithmic functions; limits; complex numbers;	
Learning goals: ➢ Gauss optics: imaging by reflexion and refraction, very thin and thick lenses, objectives, principal planes, apertures, aberrations and their corrections, the human eye, optical instruments (telescopes, collimators and auto-collimators) ➢ Wave optics: description and classification of waves; interference of two waves and N waves, interferometers, diffraction; resolution of optical instruments; light polarisation	
Contents: See learning goals	

GR: Graph Theory

Professor, Unit shortcut, and Unit name: Randerath, GR, Graph Theory (German Name: Graphentheorie)	E - S

Pre-requisites:
MA1, MA2: Mathematics 1 and 2; PI1, PI2: Practical Informatics 1 and 2; AD: Algorithms and Data Structures

Learning goals:

Module specific:
- students will have basic knowledge about graphs and algorithms
- they will be able to apply graph-theoretic models and algorithms on problems arising from computer science, engineering and real world applications
- they will know about basic results in combinatorics
- they are able to solve recursions by generating functions.
- they know about definitions, properties, representations and applications of graphs and trees
- they are able to apply Dijkstra's algorithm in order to solve the shortest path problem for weighted graphs
- they know flows and networks and how to calculate maximal flows and minimal cuts in networks
- they are able to determine (if possible) Eulerian tours, Hamiltonian tours in graphs
- they are able to determine optimal colorings in graphs.

Contents:
- **Combinatorics and countability**: foundations on finite sets and associated mappings, permutations, recursion, summations, formal power series, generating functions, solutions of recursions
- **Asymptotic analysis**: growth behaviour of functions, running time analysis of algorithms, complexity classes
- **Graphs**: definition of a graph, complete and bipartite graphs, isomorphic graphs, adjacency and incidence matrices, paths and cycles, connectivity of graphs, planar graphs, directed graphs
- **Trees**: forests, trees, minimal spanning trees, greedy-algorithms, shortest path problem, Dijkstra algorithm
- **Matchings and Networks**: matchings, networks, flows, feasible flows, Max-Flow-Min-Cut Theorem, Eulerian graphs, Hamiltonian graphs, traveling-salesman problem, algorithms and analysis
- **Colorings**: vertex colorings, chromatic number, Four-Color Theorem, edge colorings, chromatic index, coloring algorithms and its analysis

GT1: Fundamentals of Telecommunications 1: Digital Modulation

Professor, Unit shortcut, and Unit name: E - **S**

Dettmar, GT1, Fundamentals of Telecommunications 1: Digital Modulation
(German name: Grundlagen der Telekommunikation 1)

Pre-requisites:

- UET1 (fundamentals, random signals, Baseband Transmission, Matched Filter, Nyquist criteria)
- Signals and Systems 1(linear systems, impulse response and transmission function, Fourier transform)

Learning goals:

General:

- to gain knowledge about principles in digital communications
- to gain experience with the application and testing of the corresponding procedures and algorithms

Module-specific:

- to increase the knowledge of digital modulation, including bandpass systems
- to gain knowledge of the signal space concepts and the representation with orthogonal basis functions
- Line Coding
- to learn about the generation and reception of bandpass signals (ASK, PSK, QAM, and FSK), concepts for transmitters and receivers
- to learn about the effects of transmit channels as noise, fading, attenuation, interference and how to model those channels
- to understand OFDM as a way to cope with ISI and frequency selective channels

Contents:

- System model of a digital transmission link
- Line Codes
- Signal space
- Bandpass Systems
- Modulation and de-modulation of bandpass signals, performance for the AWGN channel
- Channel Modelling
- OFDM

GT2: Fundamentals of Telecomm. 2: Source and Channel Coding

Professor, Unit shortcut, and Unit name: E - **W**

Dettmar, GT2, Fundamentals of Telecommunications 2: Source and Channel Coding
(German name: Grundlagen der Telekommunikation 2)

Pre-requisites:

- Mathematics: Finite Fields
- Fundamentals of Telecommunications (GT1)
- Signals and Systems 1 and 2 (analog and digital signals and the related transform techniques)

Learning goals:

General:

- to gain knowledge about principles in digital communications
- to gain experience with the application and testing of the corresponding procedures and algorithms

Module-specific:

- to learn about basics in information theory
- to understand the principles of source and channel coding
- to learn about practical codes
- to learn about techniques to increase the transmission rate and performance

Contents:

- Quantization
- Source Coding
- Channel Coding
- Link Budget Calculation
- Spread Spectrum
- Diversity Techniques

GTI: Foundations of Technical Computer Science

Professor, Unit shortcut, and Unit name: **C - W**
Kreiser / Hartung, GTI, Foundations of Technical Computer Science
(German name: Grundlagen der Technischen Informatik)

Pre-requisites:
Basic knowledge of structured programming. Language JAVA (as e.g. provided in module PI1) or C

Learning goals:
In general:
- Provide basic theoretical foundations and practical knowledge in the design, implementation and test of digitally controlled systems (DCS), especially combinatory systems and simple finite automata

Module-specific:
- Model DCS using universal design methods, e.g. function tables, algebraic theorems, graphical system representations, automata tables, state charts
- Implement DCS on modern programmable ASICs using schematics and VHDL and/or on a modern microcontrollers / microcomputers in C programming language. Make use of implementation pattern (best practise templates)
- Simulate and test DCS to evaluate a system design and implementation

Know-how/methods/learning/social competence:
- Learn to differentiate design methods from implementation technology
- Learn to evaluate modern and future implementation technologies with respect to their usability for special purposes and their restrictions in use.
- Learn to extract relevant information out of comprehensive texts (German and English language)
- Resolve a given task in a small, often international team

Professional preparation:
- build abstract models from real world DCS of small and medium complexity
- simulate and verify model implementations to show (sufficient) equivalence between model and real world DCS before real world system launch

Contents:
- Introduction to Digital Control Systems and Technology
- Boolean Algebra, minimization, and digital basic blocks
- Data representation, coding of data
- Digital Circuits, implementation by schematics and VHDL
- Digital Sequencer and Finite State Machine (Automata)
- Programmable ASICs (CPLD)
- Introduction to Microprocessors and elementary Computer Model
- Programming Digitally Controlled Systems in C
- Implementation of Digitally Controlled Systems on µC-Systems

GUI: Graphical User Interfaces

Professor, Unit shortcut, and Unit name: Rosenthal, GUI, Graphical User Interfaces (German name: Grafische Benutzeroberflächen)	E - S
Pre-requisites: Basics of object oriented programming	
Learning goals: ➢ Students shall understand and use the concepts and interfaces of the windows API in C++ with design and programming of graphical user interfaces in mind. Furthermore students should be able to understand and use the object oriented extension of this API by encapsulation in classes. ➢ Through laboratory sessions the safety in using of GUI programming will be increased.	
Contents: This course will focus on the concepts of programming windows and events. The composition of native windows API programs will be covered as well as the encapsulation of API procedures in Borland OWL. The realization of the API in Java with AWT will be discussed and the implementation in applets, using of concurrency, and design of Java beans will be shown.	

HAST: High Voltage Engineering

Professor, Unit shortcut, and Unit name: **C - W**
Humpert, HAST, High Voltage Engineering
(German name: Hochspannungstechnik)

Pre-requisites:
GE1, GE2, PH1, PH2
fundamentals in physics and electrical engineering

Learning goals:

In general:
- students will gather knowledge on the influence of high voltage and high electric field on gaseous, liquid and solid insulators in theory and application

Module-specific:
- students will know the typical types of high voltage stress in application
- they will learn how collision processes in electronegative and electropositive gases and at electrode surfaces lead to gas discharges (Townsend theory)
- they will know the Paschen law of the breakdown in gases (especially in air and SF6)
- they will know special properties of the insulating gas SF6
- they will learn the discharge mechanism in gases in inhomogenous electrode configurations (streamer theory)
- they will know different types of discharges in homogenous and inhomogenous electrode configurations
- they will learn fundamental properties of solid and liquid dielectric insulators used in high voltage applications
- they will know the breakdown processes in solid and liquid dielectrics
- they will know the discharge process and breakdown voltage in vacuum

Know-how/methods/learning/social competence:
- students will be able to calculate the breakdown voltage of homogenous electrode configurations insulated by gaseous, liquid and solid insulators
- they will be able to calculate the inception and breakdown voltage of inhomogenous electrode configurations in gases
- they will be able to calculate the electric field strength distribution in homogenous, cylindrical and spherical electrode configuration with laminated dielectric insulators
- they will be able to dimension and design homogenous and inhomogenous electrode configurations in gaseous, liquid and solid insulators

Professional preparation:
- students are able to judge the insulating quality of electrode configurations in application
- they have learned to work in high voltage laboratories following all necessary safety regulations

Contents:

Tasks and applications of high-voltage engineering
Discharge processes in gases
- Properties of gases
- Collision processes in gases
- Townsend theory of gas discharges
- Paschen law
- Theory of streamer and leader

Breakdown in solid and liquid insulators
- Properties of solid and liquid insulators
- Electrical fields in laminated dielectrics
- Discharge processes

Vacuum insulation
- Discharge processes in vacuum
- Influence of surface properties
- Applications of vacuum insulation

HF1: High Frequency Technologies 1

Professor, Unit shortcut, and Unit name: **C - W**
Kronberger, HF1, High Frequency Technologies 1
(German name: Hochfrequenztechnik 1)

Pre-requisites:
Basic studies, GE1, GE2

Learning goals:

In general:
- students will learn fundamentals in high frequency technologies in theory and application

Module-specific:
- students will know about the range and applications of high frequency circuits
- they will learn about the parasitic effects of components at high frequencies
- they will know about the fundamentals in impedance transformation with inductances and capacitors
- they will learn how filters work and they will get fundamentals in high frequency filter design
- they will learn how to use the Smith Diagram
- they will know the theory of transmission lines and how to use transmission lines in rf circuit design
- they will know about scattering parameters and matrices

Know-how/methods/learning/social competence:
- theoretical fundamentals combined with practical examples will be explained
- students have to exercise themselves in practical circuit calculation and design
- in a work placement course they will get an introduction how to use modern rf measurement equipment
- a professional circuit simulation tool is used in parallel to support the lectures and exercises
- teaching material will be partially in English language

Professional preparation:
- they will know about the specific characteristic behaviour and differences of passive electronic circuits at high frequencies
- they have learned to use a professional circuit simulation and design tool

Contents:
- Introduction to frequency range and high frequency systems
- Material properties and passive components
- Linear, passive circuits with inductances and capacitors
- Currents, voltages and power in passive high frequency circuits
- Smith-Diagram
- Resonance circuits and filters
- Transmission line theory and application
- Impedance transformation circuits
- Scattering parameters and matrices

HF2: High Frequency Technologies 2

Professor, Unit shortcut, and Unit name: E - **S**
Kronberger, HF2, High Frequency Technologies 2
(German name: Hochfrequenztechnik 2)

Pre-requisites:
Basic studies, GE1, GE2, HF1

Learning goals:

In general:
- students will learn high frequency and microwave technologies in theory and application

Module-specific:
- students will get an introduction in microwave circuits
- they will learn about active components at high frequencies, including parasitics and noise
- they will know about the functional principle of analog rf communication systems (“*How does my radio/TV work?*”)
- they will get an introduction to Maxwell´s Equations as a basis for electromagnetic fields and waves
- they will learn how waves propagate
- they will know about waveguides
- they will learn how antennas work

Know-how/methods/learning/social competence:
- theoretical fundamentals combined with practical examples will be explained
- students have to exercise themselves in practical circuit/wave/antenna calculation and design
- in a work placement course they will get an introduction how to design simple active and passive rf/microwave circuits
- a professional circuit simulation tool is used in parallel to support the lectures, exercises and work placement
- teaching material will be partially in English language

Professional preparation:
- they will know about the specific characteristic behaviour and differences of passive and active electronic circuits at high frequencies
- they have learned to use a professional circuit simulation and design tool
- they have learned how to design a circuit

Contents:
- microstrip lines, microstrip circuits, filters, etc
- rf communication systems
- electromagnectic fields and waves
- wave propagation, polarization
- waveguides
- antennas
- antenna measurements

HFMT: High Frequency Measurement Technology

Professor, Unit shortcut, and Unit name: Schneider, HFMT; High Frequency Measurement Technology (German name: Hochfrequenzmesstechnik)	**E - W**

Pre-requisites:
Good knowledge of modules in Basic Electrical Engineering (GE1+2), Electronics (EL1+2); Mathematics (MA1+2)

Learning goals:

In general:
- students will get knowledge on basic high frequency effects and the typical measurement systems

Module-specific:
- students will know about the behavior of real passive components at high frequencies
- they will know about wave propagation on lines
- they will know about the problems of signal reflections
- they will know about the scattering parameters
- they will know how to analyze and design matching circuits using the smith chart
- they will know the principle of frequency mixing
- they will know the function of basic RF measurement systems

Know-how/methods/learning/social competence:
- students will be able to investigate multiple reflections in systems
- they will be able to design matching circuits
- they will be able to determine the signal flow in RF systems
- they will be able to apply the heterodyne mixing process
- they will be able to use a standard RF simulation tool
- they will be able to work with standard RF measurement systems

Contents:
- Changes of component characteristics at high frequency signals
- Waves and their propagation on lines, the reflection coefficient Γ, line impedance Z_0
- Characterization of RF circuits using the scattering parameters, the transmission parameters and the ABCD parameters
- Introduction of the Smith Chart, analysis and design of matching circuits with the Smith Chart
- Description of the signal transfer using the signal flow diagram
- The heterodyne principle
- Introduction into the function of basic RF measurement systems

HFS1: High Frequency Circuits 1

Professor, Unit shortcut, and Unit name: **E - W**
Schneider, HFS1; High Frequency Circuits 1
(German name: Hochfrequenzschaltungstechnik 1)

Pre-requisites:
Good knowledge of modules in Basic Electrical Engineering (GE1+2), Electronics (EL1+2); Mathematics (MA1+2)

Learning goals:

In general:
- students will get knowledge on basic high frequency effects and the typical measurement systems

Module-specific:
- students will know about the behavior of real passive components at high frequencies
- they will know about wave propagation on lines
- they will know about the problems of signal reflections
- they will know about the scattering parameters
- they will know how to analyze and design matching circuits using the smith chart
- they will know the principle of frequency mixing
- they will know the function of basic RF measurement systems

Know-how/methods/learning/social competence:
- students will be able to investigate multiple reflections in systems
- they will be able to design matching circuits
- they will be able to determine the signal flow in RF systems
- they will be able to apply the heterodyne mixing process
- they will be able to use a standard RF simulation tool
- they will be able to work with standard RF measurement systems

Contents:
- Changes of component characteristics at high frequency signals
- Waves and their propagation on lines, the reflection coefficient Γ, line impedance Z_0
- Characterization of RF circuits using the scattering parameters, the transmission parameters and the ABCD parameters
- Introduction of the Smith Chart, analysis and design of matching circuits with the Smith Chart
- Description of the signal transfer using the signal flow diagram
- The heterodyne principle
- Introduction into the function of basic RF measurement systems

HFS2: High Frequency Circuits 2

Professor, Unit shortcut, and Unit name: **Eg - S**
Schneider, HFS2; High Frequency Circuits 2
(German name: Hochfrequenzschaltungstechnik 2)

Pre-requisites:
High Frequency Circuits 1 (HFS1) or High Frequency Technologies 1 (HF1), alternatively

Learning goals:

In general:
- students will get knowledge on the function and the design of high frequency circuits

Module-specific:
- students will know about the effects of noise and its calculation
- they will know about phase shifter structures
- they will know about the function of line couplers
- they will know different mixer topologies
- they will know about stability problems in RF circuits
- they will know how to design RF transistor amplifiers

Know-how/methods/learning/social competence:
- students will be able to calculate noise and the noise figure of components
- they will be able to design phase shifter circuits
- they will be able to design planar line couplers
- they will be able to apply different mixer concepts
- they will be able to determine the stability of active circuits
- they will be able to design simple amplifier structures
- they will be able to work with a standard RF simulation tool
- they will be able to layout planar RF circuits

Contents:
- Noise effects, noise figure, noise temperature
- Passive circuits, phase shifter, planar line coupler
- Mixer structures
- Stability of active circuits
- RF transistor amplifier

HFST: High Frequency Circuits

Professor, Unit shortcut, and Unit name: **E - S**
Schneider, HFST; High Frequency Circuits
(German name: Hochfrequenzschaltungstechnik)

Pre-requisites:
High Frequency Measurement Technology (HFMT) or High Frequency Technologies 1 (HF1), alternatively

Learning goals:

In general:
- students will get knowledge on the function and the design of high frequency circuits

Module-specific:
- students will know about the effects of noise and its calculation
- they will know about phase shifter structures
- they will know about the function of line couplers
- they will know different mixer topologies
- they will know about stability problems in RF circuits
- they will know how to design RF transistor amplifiers

Know-how/methods/learning/social competence:
- students will be able to calculate noise and the noise figure of components
- they will be able to design phase shifter circuits
- they will be able to design planar line couplers
- they will be able to apply different mixer concepts
- they will be able to determine the stability of active circuits
- they will be able to design simple amplifier structures
- they will be able to work with a standard RF simulation tool
- they will be able to layout planar RF circuits

Contents:
- Noise effects, noise figure, noise temperature
- Passive circuits, phase shifter, planar line coupler
- Mixer structures
- Stability of active circuits
- RF transistor amplifier

HLP: Higher Layer Protocols

Professor, Unit shortcut, and Unit name: Leischner (FH BRS), HLP, Higher Layer Protocols (German name: Protokolle höherer OSI-Schichten)	Cg - W
Pre-requisites:	
Learning goals: ➢	
Contents: ➢ Introduction into higher layer protocols ➢ Requirements analysis and protocol design (with TCP as example protocol) ➢ Requirements of the network management, and the protocol SNMP ➢ E-business communication ➢ Further protocol examples	

HO: Holography

Professor, Unit shortcut, and Unit name: E - **S**
(NF Gutjahr), HO, Holography
(German name: Holographie)

Pre-requisites:
MA1, MA2, GO, WO
Integrals; Derivatives; trigonometric, exponential, limits; series; complex numbers; Fourier series; geometrical optics

Learning goals:

In general:
- Students learn about display holography and holographic measurement

Module-specific:
- students will learn to understand how holography works
- they will learn to describe the holographic image using interference and diffraction
- they will learn the basics of speckle interferometry
- they will learn how to evaluate holographic measurement images

Know-how/methods/learning/social competence:
- the students will learn the different methods for making display holograms
- they will learn which film and chemical development is needed
- they will learn how to reconstruct a hologram depending on the exposure situation
- they will learn to measure displacement and vibration using holographic film
- they will learn to measure displacement and vibration using a ccd camera and a computer

Professional preparation:
- the students will learn the theory of the holographic image
- they will learn how to set up the different holographic techniques

Contents:
- mathematical description of holography
- description of the holographic object using amplitude and phase
- grating and zone plate as simple holograms, diffraction for reconstruction of a hologram
- theoretical description and experimental setup of the following display holograms: in-line (Gabor), off-axis (Leith-Upatnieks), white-light-reflection (Denisyuk), rainbow (Benton).
- holographic copies
- reconstruction of these holograms, real image, virtual image, orthoscopic image, pseudoscopic image
- holographic measurement: double exposure hologram for deformation measurement, time average hologram for vibration measurement
- speckle interferometry for holographic measurements. Phase shift for reconstruction the phase information of the object.

HPH: Higher Physics/Quantum Mechanics

Professor, Unit shortcut, and Unit name: Welker, HPH, Higher Physics/Quantum Mechanics (German name: Höhere Physik/Quantenmechanik)	**?? - W**
Pre-requisites: PH1, MA1, MA2?, GE1, GE2? fundamentals in physics; advanced knowledge in mathematics and electrical engineering	
Learning goals: In general: ➢ students will realize the necessity of quantization of physical quantities and the wave-particle dualism ➢ they will learn solution methods for complex differential equations using separation statements, expansion in power series, consideration of boundary conditions and asymptotic behavior. Introduction of Eigenfunctions&Eigenvalues and operators Module-specific: ➢ Know-how/methods learning/social competence: ➢ students will gain profound theoretical physical knowledge ➢ they will train their physical awareness for technical questions Professional preparation: ➢ students learn to realize complex physical contexts ➢ they will be able to identify, evaluate, and compare essential parameters ➢ they train to become acquainted with theoretical questions	
Contents: ➢ inadequacy of classical Physics: black body radiator, specific heats of solids, photoelectric effect, Compton-effect, Stern-Gerlach experiment, Bohr's model, material waves ➢ experiments with spheres, waves ad electrons, basic principles of quantum mechanics, ➢ uncertainty principle ➢ wave function, particles and probability amplitude: combination law of amplitudes, identical particles ➢ Schrödinger equation: development of the wave equation, simple square potentials, harmonic oscillator, system of many particles ➢ application of Quantum mechanics: the H-atom, the solid ➢ perturbation theory	

HS1: High Voltage Engineering 1

Professor, Unit shortcut, and Unit name: **C - W**
Humpert, HS1, High Voltage Engineering 1
(German name: Hochspannungstechnik 1)

Pre-requisites:
GE1, GE2, PH1, PH2
fundamentals in physics and electrical engineering

Learning goals:

In general:
- students will gather knowledge on the influence of high voltage and high electric field on gaseous, liquid and solid insulators in theory and application

Module-specific:
- students will know the typical types of high voltage stress in application
- they will learn how collision processes in electronegative and electropositive gases and at electrode surfaces lead to gas discharges (Townsend theory)
- they will know the Paschen law of the breakdown in gases (especially in air and SF6)
- they will know special properties of the insulating gas SF6
- they will learn the discharge mechanism in gases in inhomogenous electrode configurations (streamer theory)
- they will know different types of discharges in homogenous and inhomogenous electrode configurations
- they will learn fundamental properties of solid and liquid dielectric insulators used in high voltage applications
- they will know the breakdown processes in solid and liquid dielectrics
- they will know the discharge process and breakdown voltage in vacuum

Know-how/methods/learning/social competence:
- students will be able to calculate the breakdown voltage of homogenous electrode configurations insulated by gaseous, liquid and solid insulators
- they will be able to calculate the inception and breakdown voltage of inhomogenous electrode configurations in gases
- they will be able to calculate the electric field strength distribution in homogenous, cylindrical and spherical electrode configuration with laminated dielectric insulators
- they will be able to dimension and design homogenous and inhomogenous electrode configurations in gaseous, liquid and solid insulators

Professional preparation:
- students are able to judge the insulating quality of electrode configurations in application
- they have learned to work in high voltage laboratories following all necessary safety regulations

Contents:

Tasks and applications of high-voltage engineering
Discharge processes in gases
- Properties of gases
- Collision processes in gases
- Townsend theory of gas discharges
- Paschen law
- Theory of streamer and leader

Breakdown in solid and liquid insulators
- Properties of solid and liquid insulators
- Electrical fields in laminated dielectrics
- Discharge processes

Vacuum insulation
- Discharge processes in vacuum
- Influence of surface properties
- Applications of vacuum insulation

HS2: High Voltage Engineering 2

Professor, Unit shortcut, and Unit name: **E - S**
Humpert, HS2, High Voltage Engineering 2
(German name: Hochspannungstechnik 2)

Pre-requisites:
PH1, PH2, MA1, MA2, GE1, GE2
fundamentals in physics and mathematics; advanced knowledge in electrical engineering

Learning goals:

In general:
- students will gather knowledge on generating, propagation, measuring and limiting of high voltages in order to test and to protect high voltage equipment

Module-specific:
- students will learn how AC, DC and impulse voltages are generated in high voltage laboratories
- they will learn to measure high AC, DC and impulse voltages with measuring spark gaps and voltage dividers
- they will learn how the testing and measuring equipment must be designed to avoid damages
- they will know the origin of overvoltages, like lightning impulse and switching impulse voltages
- they gather knowledge about limiting of high overvoltages with spark gaps and surge arresters
- students will learn the origin and impact of travelling waves

Know-how/methods/learning/social competence:
- students will be able to dimension high voltage transformers for the application in high voltage laboratories
- they will be able to calculate the maximum possible currents of Greinacher cascades for the generation of DC voltages
- they will be able to dimension Marx generators to generate impulse voltages with given time constants
- they will be able to design voltage dividers to measure different types of high voltages
- they will be able to judge the accuracy of measurement with different equipment
- they will be able to calculate the limited range of surge arresters

Professional preparation:
- students can plan and perform tests of high voltage equipment following actual standards
- they will be able to judge the insulating quality on the basis of high voltage test results

Contents:

Generating of high test voltage
- Generation of AC voltages with transformers and cascades of transformers
- Generation of DC voltages with rectifier circuits, Greinacher cascade and van de Graaf generator
- Generation of impulse voltages with Marx generators

Measuring of high voltages
- Measuring spark gap
- High voltage dividers, transfer function
- Instrument transformers
- Partial discharge measurement

Limiting of overvoltages
- Sources of overvoltages
- Travelling waves
- Lightning and surge arresters

HSPM: High Voltage Testing and Measurement Technology

Professor, Unit shortcut, and Unit name: **Eg - S**

Humpert, HSPM, High Voltage Testing and Measurement Technology
(German name: Hochspannungsprüftechnik und -messtechnik)

Pre-requisites:

PH1, PH2, MA1, MA2, GE1, GE2
fundamentals in physics and mathematics; advanced knowledge in electrical engineering

Learning goals:

In general:

- students will gather knowledge on generating, propagation, measuring and limiting of high voltages in order to test and to protect high voltage equipment

Module-specific:

- students will learn how AC, DC and impulse voltages are generated in high voltage laboratories
- they will learn to measure high AC, DC and impulse voltages with measuring spark gaps and voltage dividers
- they will learn how the testing and measuring equipment must be designed to avoid damages
- they will know the origin of overvoltages, like lightning impulse and switching impulse voltages
- they gather knowledge about limiting of high overvoltages with spark gaps and surge arresters
- students will learn the origin and impact of travelling waves

Know-how/methods/learning/social competence:

- students will be able to dimension high voltage transformers for the application in high voltage laboratories
- they will be able to calculate the maximum possible currents of Greinacher cascades for the generation of DC voltages
- they will be able to dimension Marx generators to generate impulse voltages with given time constants
- they will be able to design voltage dividers to measure different types of high voltages
- they will be able to judge the accuracy of measurement with different equipment
- they will be able to calculate the limited range of surge arresters

Professional preparation:

- students can plan and perform tests of high voltage equipment following actual standards
- they will be able to judge the insulating quality on the basis of high voltage test results

Contents:

Generating of high test voltage

- Generation of AC voltages with transformers and cascades of transformers
- Generation of DC voltages with rectifier circuits, Greinacher cascade and van de Graaf generator
- Generation of impulse voltages with Marx generators

Measuring of high voltages

- Measuring spark gap
- High voltage dividers, transfer function
- Instrument transformers
- Partial discharge measurement

Limiting of overvoltages

- Sources of overvoltages
- Travelling waves
- Lightning and surge arresters

IBV1: Industrial Computer Vision 1

Professor, Unit shortcut, and Unit name: **E - W**
Thieling, IBV1, Industrial Computer Vision 1
(German name: Industrielle Bildverarbeitung 1)

Pre-requisites:
Common mathematics

Learning goals:
The main goal is, to obtain basic knowledge about image-enhancement (pre-processing) and the way how to create a solution for simple inspection tasks by using image processing.

Contents:

- **Image representation:**
  neighbourhood relation
  discrete geometry
  grey-scale and colour images
  brightness and colour resolution
- **Global feature and image restoration**
  statistical characteristics (mean-value, contrast, entropy)
  histogram modification
  linear grey-level scaling
  histogram equalisation
- **Presentation and processing of images in frequency domain**
  Fourier transformation (one dimensional)
  properties of the fourier transformation
  discrete fourier transformation (one dimensional)
  two dimensional discrete Fourier transformation of images
  linear filters
  inverse filters
- **Filtering in spatial domain**
  convolution
  correspondence between convolution and filtering in frequency domain (transfer function)
  low-, high,- and band-pass like filters
  non-linear filters (rang-order-filters)
- **Morphological operators**
  erosion, dilatation, opening, closing
  morphological processing of binary images
  morphological processing of grey-level images
- **Segmentation**
  histogram based segmentation
  shading
  labelling
  split- and merge
  region-growing
- **Feature extraction**
  features from colour (RGB- and HSI-Colour-Space)
  features from shape

IBV2: Industrial Computer Vision 2

Professor, Unit shortcut, and Unit name: **E - S**
Thieling, IBV2, Industrial Computer Vision 2
(German name: Industrielle Bildverarbeitung 2)

Pre-requisites:
Topics from Industrial Computer Vision 1

Learning goals:
The main goal is, to obtain knowledge about how to create solution for sophisticated classification- and inspection-tasks by using image processing.

Contents:
- **Edge detection and measurement**
  gradient
  operators for enhancement and detection of edges
  sub pixel edge detection
- **Segmentation using contours**
  contours from binary images
  contours from gradient images
  approximation of contours
- **Feature extraction**
  hough transformation
  features from contours
  polar-distance
  discrete Fourier transformation of contours
- **Classification**
  normalized cross-correlation
  features and feature space
  kind of classification (supervised, non-supervised, self-learning)
  minimum distance classification
  nearest neighbour classification
  maximum likelihood classification
  neuronal networks (multilayer perceptron with back propagation)
- **Image acquisition systems**
  optics
  CCD-camera
  video-signal
  frame-grabber
- **Measuring using CCD-cameras and image processing**
  modelling of the image acquisition system
  camera-calibration
  2D-measurement using calibrated cameras
  3D-measurement (stereo vision, structured light)

IN1: Practical Informatics 1

Professor, Unit shortcut, and Unit name: **C - W**
Vogt / Büchel / Rosenthal, IN1, Practical Informatics 1
(German name: Praktische Informatik 1)

Pre-requisites:
None.

Learning goals:
- Learn about fundamental concepts and techniques of Practical Informatics.
- Learn to solve small-size application problems algorithmically.
- Write programs in an object-oriented language (i.e. Java).

Contents:
- Operating principle of a digital computer.
- Algorithms and programs.
- Scalar and structured data types in Java.
- Control structures in Java.
- Methods in Java.
- Objects, classes, and class hierarchies in Java.

IN2: Practical Informatics 2

Professor, Unit shortcut, and Unit name: **C - S**
Vogt / Büchel / Rosenthal, IN2, Practical Informatics 2
(German name: Praktische Informatik 2)

Pre-requisites:
Practical Informatics 1.

Learning goals:
- Learn about fundamental concepts and techniques of Practical Informatics.
- Learn to solve small-size application problems algorithmically.
- Write programs in an object-oriented language (i.e. Java).

Contents:
- Programming with Java class hierarchies and standard packages.
- Formal specification of syntactical structures.
- Exception handling in Java.
- Graphical user interfaces in Java.
- Basic concepts of UML.
- Dynamic data structures, graphs.

INS: Information Security

Professor, Unit shortcut, and Unit name:	Cg - W
Pohl (FH BRS), INS, Information Security (German name: Informationssicherheit)	

Pre-requisites:
KRY

Learning goals:
-

Contents:
- Basics of Regulations, technical management of information security in CE
- Models and quantitative information security: metrics and rating methods
- Trust management
- Systems generating security
- Other mechanisms controlling and evaluating trust
- Net security, mobile security
- Secure software engineering: design, implementation, tests

ITAU: Information Engineering for Automation

Professor, Unit shortcut, and Unit name: Große / Schellong, ITAU, Information Engineering for Automation (German name: Informationstechnik in der Automatisierungstechnik)	**E - S**

Pre-requisites:
MA1, MA2, IN1, IN2
differential and integral calculus, algorithms, basics in software engineering

Learning goals:

In general:
- students will gather knowledge on information systems and data management in industrial enterprises as well as in energy supply companies

Module-specific:
- students will know about the modelling of the structure of an enterprise by different levels
- they will know about the necessary informational technologies for data management
- they will know about the objectives and structure of control and information systems in the different levels of the enterprise
- they will learn how to analyze the data flow from the process control system to other control systems in the different levels of the enterprise
- they will know the main ideas of software engineering methods
- they will know the objectives and methods for system integration
- they will know about project management methods

Know-how/methods/learning/social competence:
- students will be able to apply the control and informational tools for the analysis and development of information systems
- they will be able to apply suitable technologies for the system integration
- they will learn the interdisciplinary character of applied project work in the field of automation and information engineering
- they will learn how to build up a “virtual consulting company” and to work in a project team
- they will be able to represent their results by computer aided presentations

Professional preparation:
- students can work on actual problems in the fields of automation, process control, software engineering
- they have learned to apply combined methods for analyzing and optimizing industrial information systems

Contents:
- modelling of the structure of an enterprise by different levels
- objectives and structure of information systems in the different levels in industrial enterprises and in energy supply companies
- software engineering methods (structured and object-oriented software design)
- relational databases
- process control level
- operating control level
- system integration
- operating systems and networks
- data protection
- project management
- project work in a "virtual consulting company"
- presentation of the results of the project work

KA: Communication in Automation Systems

Professor, Unit shortcut, and Unit name: **E - S**
Bartz, KA, Communication in Automation Systems
(German name: Kommunikation in der Automatisierung; Feldbusse und dezentrale Automatisierung 2)

Pre-requisites:
FG, TI1
digital logic circuits; binary numbers; C-programming; fundamentals of ISO/OSI communication; physical layer and data link layer concepts

Learning goals:

In general:
- students will gather deeper knowledge on typical communication mechanisms with special focus on the fieldbus area and layer 7

Module-specific:
- students will know about the major network topologies
- they will know about the principles of layer 1 and 2 of the Interbus-S communication solution (ring topology, specific transmission protocol,...)
- they will know about the principles of layer 1 and 2 of the Profibus communication solution (token management; service groups; transmit/receive buffers;...)
- they will know about the most important characteristics of layer 7 solutions in the fieldbus area (objects, services, directories, access control mechanism,...)

Know-how/methods/learning/social competence:
- students will be able to determine benefits and drawbacks of different communication solutions
- they will be able to engineer communication solutions in the fieldbus area
- they will have gained experiences with topics that contain a huge amount of detail information
- they will have gained practical experiences in implementing CAN-based communication as well as sensor and actor access in a microcontroller environment (C167 controller, programmed in C)
- they will gather practical experiences in team-based design tasks

Professional preparation:
- students deepen their hands-on experience with embedded systems and a microcontroller (incl. symbolic debugging)
- they gather first experiences in implementing CAN-based communication
- they deepen their experiences in accessing sensors and actors in an embedded environment

Contents:
- Interbus-S: basics of layer 1 and layer 2
- Profibus: basics of layer 1 and layer 2
- importance and major characteristics of layer 7 in a fieldbus environment
- specific characteristics of layer 7 of the Interbus-S communication solution (similar to FMS and MMS)
- practical experiences: continued design and implementation of C programs for a microcontroller (C167) in order to access local sensors and actors and to send and receive CAN messages

KC: Advanced Channel Coding

Professor, Unit shortcut, and Unit name: Eg - **W**

Dettmar, KC, Advanced Channel Coding
(German name: Kanalcodierung)

Pre-requisites:

Finite Fields, Advanced Mathematics, basics in digital communications

Learning goals:

In general:

- to gain knowledge about principles in error correcting codes
- to gain experience with the application and testing of the corresponding procedures and algorithms

Module-specific:

- to learn basics on information theory
- to understand the principles and the use of channel coding
- to learn about practical codes and their implementation
- to learn about techniques to increase the transmission rate and performance of digital systems

Know-how/methods/learning/social competence:

- they will be able to estimate the feasibility of digital transmission links
- they will train their algorithmic thinking
- they will be able to determine achievable data rates
- they will learn how to get into a demanding technical area
- they will be confronted with English language text books.

Professional preparation:

- students know basics on error correcting codes and can judge their usability for user defined applications
- they learn basics on algorithms and their implementation

Contents:

Some principles on Information Theory

- System Model
- Channel Coding Theorem
- Channel Capacity
- Example Calculations

Review of Error Correcting Block and Convolutional Codes

- Review of Linear Block Codes and Convolutional Codes, Generator and Parity check matrices, decoding principles, Trellis and Viterbi Algorithm

Reed Solomon Codes

- Encoding and Decoding, Euklidean and Berlekamp-Massey Algorithm for Decoding

Trellis and Block Coded Modulation

- Design of Trellis Codes, Decoding for the AWGN Channel
- Design of BCM Codes, Multilevel Decoding

Basics on LDPC and TURBO Codes

- Low Density Parity Check Codes and Gallagers Decoding Algorithm
- Recursive Convolutional Codes and the iterative decoding algorithm

Basics on Space Time Coding

- Channel Model, Capacity improvement, Alamouti Scheme, STBC and STTC and their decoding

KLE: Cables and flexible cords for power distribution and automation

Professor, Unit shortcut, and Unit name: **Eg - S**
Späth, KLE, Cables and flexible cords for power distribution and automation applications
(German name: Kabel und Leitungen für die Energie- und Automatisierungstechnik)

Pre-requisites:
MA1, MA2, GE1, GE2, GE3 all completely

Learning goals:
- The students should be in the position to choose the necessary cables and flexible cords in planning and projecting problems in the power supply and in the automation technology under considering the very varied, different conditions.
- In addition, the Students should receive the for an engineer in the Cable Industry necessary basic skills

Contents:
- Theoretical Foundations:
  line equations, calculation of the line parameters, transmission lines, capacity fundamentals of fiber optic cable, materials theory
- Construction of cables and wires:
  construction elements, materials , technology of cable and wire production, accessories
- Standards and Regulations:
  construction standards, applying standards, testing regulations, international Standards
- Cables for fixed applications:
  cables for high-, medium- and low voltage, halogenfree cables
- Cables for automation lines:
  Heavy-current and control cables, data and bus cables, fiber-optic cables

KRY: Cryptography

Professor, Unit shortcut, and Unit name: **Cg - W**

Knospe, KRY, Cryptography
(German name: Kryptographie)

Pre-requisites:

MA1, MA2
Adequate knowledge of basic mathematics (calculus, linear algebra, probability theory), programming languages (Java and C), operating systems (in particular Unix/Linux). English language skills are required (English lecture notes).

Learning goals:

- The students know the fundamentals of cryptography from algebra, number theory and statistics.
- They know the objectives of cryptography and cryptanalysis.
- They are proficient in symmetric and asymmetric cryptography and know the complexity of the mechanisms and possible attacks.
- The students can apply cryptographic schemes in order to attain security objectives.

Contents:

- Introduction to information security and cryptography
- Mathematical background: Groups, rings, rings of integers, polynomials and residue classes, primes, fields GF(p) and GF(p^n), modules over rings and their homomorphisms
- Algorithms and their complexity
- Cryptographic systems and crypto protocols
- Classical ciphers, mono- and polyalphabetic ciphers, affine ciphers and their cryptanalysis
- Symmetric-key encryption: block ciphers, operation modes, DES cipher and its cryptanalysis, AES cipher, stream ciphers, Linear Feedback Shift Register, GSM encryption, RC4, One-Time-Pad, perfect secrecy, Pseudo Random Bit Generators
- Public-key algorithms: One-way functions, primality testing, RSA, complexity and attacks, discrete logarithm, Diffie-Hellmann key exchange, ElGamal
- Cryptographic hash functions, collision resistance, MD5, SHA1, RSA signature, ElGamal signature, DSS, Message Authentication Codes (MAC)

LA1: Linear Algebra 1

Professor, Unit shortcut, and Unit name: Knospe, LA1, Linear Algebra 1 (German name: Lineare Algebra 1)	C - W
Pre-requisites: High school mathematics	
Learning goals: To impart fundamental mathematical knowledge about Linear Algebra.	

Contents (LA1 covers the Linear Algebra part of the following topics):

- Fundamentals about sets and mappings
- Natural, integer, rational, real numbers, fields
- Divisibility, residue classes, finite fields
- Propositional logic
- Equations, inequations and their solutions
- Real functions and their properties
- Injective, surjective, bijective, inverse functions
- Polynomials
- Rational -, trigonometric -, power -, root -, exponential -, logarithmic functions

- Limits and continuity
- Differential calculus: derivative, differentiation formulas
- Monotony, max-min problems
- L'Hospital's rule
- Tangents, Taylor polynomials, Taylor series
- Newton's method

- Vectors and vector spaces over fields
- Scalar product, norm, angle, orthogonality, vector product
- Lines, planes
- Matrices, matrix operations
- Systems of linear equations, Gaussian elimination

LA2: Linear Algebra 2

Professor, Unit shortcut, and Unit name: Knospe, LA2, Linear Algebra 2 (German name: Lineare Algebra 2)	**C - S**
Pre-requisites: LA1, AN1	
Learning goals: To impart fundamental mathematical knowledge about Linear Algebra.	
Contents (LA2 covers the Linear Algebra part of the following topics): ➢ Complex numbers, cartesian form, polar form ➢ Roots and powers of complex numbers ➢ Euler relationship, complex exponential ➢ Riemann integral ➢ Fundamental theorem of calculus ➢ Definitive and indefinitive integral ➢ Integration of elementary functions ➢ Techniques of integration ➢ Complex integration ➢ Linear differential equations with constant coefficients ➢ Functions of several real variables ➢ Partial derivatives, gradient, tangent plane ➢ Linear mappings (over arbitrary fields) and their matrices ➢ Matrices, determinants, Laplace expansion ➢ Cramer's rule ➢ Inverse matrix ➢ Eigenvalues and eigenvectors ➢ Linear (in-)dependence, basis, coordinates, dimension ➢ Symmetric, orthogonal matrices ➢ Change of basis	

LB1: Lighting Engineering and Technology

Professor, Unit shortcut, and Unit name: Gornik, LB1, Lighting Engineering and Technology (German name: Licht- und Beleuchtungstechnik) E - **W**
Pre-requisites: MA1, MA2, GE1, GE2, PH1, PH2
Learning goals: In general: ➢ Students will get across with the specialist methods in Lighting Engineering and Technology Module-specific: ➢ Students will know the principles of Photometry and Colorimetry ➢ They will know the equipment and devices for light measurement ➢ They will know the physical principles of generation of light ➢ They will have an overview about technical light sources (lamps), their operating supplies, with their electrical, optical, material and ergonomic characteristics Professional preparation: ➢ Application-oriented engineering work in the lighting industry Further goals: ➢ Synthesis of so far acquired engineering knowledge with physiological (human eye), psychological, and economic aspects
Contents: ➢ Basics of electromagnetic radiation, light measurement and geometry ➢ Principles of the Photometry ➢ Introduction into the Colorimetry ➢ Physical principles of light generation ➢ Equipment and devices for light measurement ➢ Overview about the lighting, electrical and producer specific properties of technical light sources (lamps)

LB2: Lighting Engineering and Technology - Selected Topics

Professor, Unit shortcut, and Unit name: Eg - **S**

Gornik, LB2, Lighting Engineering and Technology - Selected Topics
(German name: Ausgewählte Kapitel der Licht- und Beleuchtungstechnik)

Pre-requisites:
MA1, MA2, GE1, GE2, PH1, PH2, LB1

Learning goals:

In general:

- Students will get across with the advanced methods in Lighting Engineering and Technology

Module-specific:

- With the acquired knowledge in basics (LAT1), Students will know about the application of Lighting Technology: multiple coach lighting, workplace lighting, outdoor lighting, economic and ergonomic aspects, integrating of daylight, lighting control
- They will be able to apply calculation programs for lighting design
- Students will be able to solve problems in Lighting Engineering and Technology
- They will be able to take into the consideration the physiological and psychological aspects by application of lighting

Professional preparation:

- Application-oriented engineering work and research in the lighting industry
- Basics for training of specialists of lighting

Further goals:

- Synthesis of so far acquired engineering knowledge with physiological (human eye), psychological, and economic aspects
- Know-how methods of learning, social competence

Contents:

- Short summary of the basic knowledge in Lighting Engineering and Technology
- Technological aspects of lighting and illumination in reference to ergonomy and economy
- Presentation of relevant standards in technical lighting
- Lighting control
- Principles of lighting design
- Day lighting
- Energy saving in technical lighting
- Calculation programs for lighting

LE: Power Electronics

Professor, Unit shortcut, and Unit name: (NF van der Broeck), LE, Power Electronics (German name: Leistungselektronik)	**C - W**
Pre-requisites: Mathematics 1+2, Electrical Engineering 1+2	
Learning goals: In general: ➢ The students learn the basic principles of electronic power conversion Module-specific: ➢ The lecture deals with line commutated rectifiers and with transistor inverters. ➢ The students understand the importance of power electronics for efficient conversion and control of electrical power. Professional preparation: ➢ Within the lecture state of the art power electronics components and circuits from industry applications are presented	
Contents: ➢ Properties of non sinusoidal signals in time and frequency domain. ➢ Energy storage in inductors and capacitors ➢ Basic principles of power electronic circuits ➢ Uncontrolled line rectifiers M2,B2,M3,B6 ➢ Line commutated rectifier circuits ➢ Power quality ➢ Active, reactive and distorted power ➢ Power semiconductor switches GOTO MOSFET IGBT ➢ Step down and step up chopper ➢ Two level current control of converters ➢ Transistor half- and full-bridge topologies ➢ Pulse width modulation PWM ➢ Generation of sinusoidal currents and voltages ➢ Uninterruptible power supplies ➢ Simulation tools for power electronics	

LM: Light Microscopy

Professor, Unit shortcut, and Unit name:	E - W
Altmeyer, LM, Light Microscopy (German name: Licht-Mikroskopie)	

Pre-requisites:

Mathematics 1&2, Physics 1&2, Optics 1&2, Wave-optics, Applied Optics
Higher mathematics, basic knowledge in physics, beam optics and wave optics

Learning goals:

In general:

- Concepts of modern imaging technologies and their theoretical foundations. Practical experience with modern microscopes.

Know-how/methods/learning/social competence:

- The module is thought to deepen the knowledge in the theoretical backgorunds of imaging technologies. The additional mandatory practical trainings give a strong link to real life applications and problems. Additionally the hands on experiments provide an ease of handling of high end microscopy equipment.

Professional preparation:

- Students are to comprehend, that constructs of ideas, which are difficult to understand at a first glance, are ubiquitous in today's technical products. Therefore the related ultimate principles have to be understood as a conditio sine qua non. The additional hands on experiences with such high end equipment dispells existing reservations.

Contents:

- Amplitude Microscopy:
  Amplitude objects, Lambert’s law, Abbe’s theory of imaging, phase relations in the different diffraction orders for amplitude objects, aperture and field stops, interwoven optical paths for transmission and reflection microscopes with Koehler illumination
- Phase Microscopy:
  phase objects, phase relations in the different diffraction orders for amplitude and phase objects, phase shift arrangements: small disk and Zernicke-ring, Calculation of the contrast function for a Zernicke phase microscope.
- Interference Microscopy:
  Spatial and temporal coherence, interference, for Mach-Zehnder interferometer and Michelson interferometer: equal optical paths, compensation plates, phase lepas, complementarity of the interference patterns, requirements on coherence ; Interference Microscopy setups according to Linnik, Michelson and Mirau ; Shearing and Differential Interference Contrast (DIC) systems, multiple beam interference and Tolansky systems

LM1: Luminescent Materials

Professor, Unit shortcut, and Unit name: E - **W**
Welker, LM1, Luminescent Materials
(German name: Lumineszierende Materialien)

Pre-requisites:
PH1, MA1, MA2?, GE1, GE2?
Fundamentals in physics; advanced knowledge in mathematics and electrical engineering

Learning goals:

In general:
- students will learn fundamentals about luminescence, especially in solid materials
- they will gain knowledge on applications of this process in display and illumination technologies as well as in sensors

Module specific:
-

Know-how/methods/learning/social competence:
- students will learn theoretical knowledge in seminars
- they will train the practical applications of their knowledge in experimental projects
- they will work in teams simulating the tasks of the development division/department (e.g. quality improvement and competitor analysis)

Professional preparation:
- students learn to plan a project and to realize it in the laboratory
- they document and vindicate the results in their teams

Contents:
- fundamentals: light, electrons, lattice vibrations (phonons), electronic band structure, localized electronic states, excitation- and recombination- processes
- photo-, cathodo-, radio- and elektroluminescence
- phosphors: (materials, properties, activators) excitation-, emission-spectra, quantum yield, radiant efficiency
- technical applications: CRT, fluorescent lamps, flad displays, X-ray detectors, LEDs, OLEDS, EL-lamps, high field-EL-structures
- recent developments in the field of luminescent materials

LS: Laser Radiation Protection

Professor, Unit shortcut, and Unit name: E - ??
Reidenbach, LS, Laser Radiation Protection
(German name: Laserstrahlenschutz)

Pre-requisites:
Fundamentals in physics

Learning goals:

In general and module-specific:

- The module presents the expert knowledge in laser radiation protection.

Know-how/methods/learning/social competence:
- The necessary fundamentals in laser radiation protection are presented based on the existing regulations and international standards.
- Actual topics will be presented by the students in a seminar and discussed.

Professional preparation:
- The students become familiar with the special field of laser radiation protection according to the requirements given by labor protection laws and the valid executive order laws in industrial and public area. They will be trained in the respective topics in order to fulfil the position of a laser safety officer, which is required in typical laser applications.
- The presentation of topics in a seminar and the supplementary discussion improves the know-how and the soft skills simultaneously.

Contents:
- Basics in laser technology
- Beam characteristics
- Interaction of laser radiation with biological material
- Eye and skin hazards
- Maximum permissible exposure
- Laser classification
- Safety requirements in standards
- Regulations for the prevention of industrial accidents
- Protection measures against laser radiation
- Laser safety goggles and adjustment goggles
- Applications

LT: Laser Technology

Professor, Unit shortcut, and Unit name: **C - W**

Altmeyer, LT, Laser Technology
(German name: Lasertechnik)

Pre-requisites:

MA1, MA2, PH1, PH2, GE1, GE2, OT1, OT2
Higher mathematics, basic knowledge physics incl. atomic models, electrodynamics, beam optics and wave optics

Learning goals:

In general:

- Coherence, setup and principle of operation of lasers, deeper physical background

Know-how/methods/learning/social competence:

- Lasers are the only temporal and spatial highly coherent source of light. Starting with the idea of coherence this module is thought to give a deep insight into the generation, shaping and utilization of highly coherent light fields. The link to applications is given by many examples from industrial best practice.

Professional preparation:

- With more than 20 % world market share Germany is technology- and market leader in laser technologies. Besides its fabrication the laser has found its way into the following key industries: production, metrology, information & communication, medicine and biotechnology. In all these sectors highly skilled graduates are required. It is expected that they have a good understanding of the laser and are able to perform application specific customizations.

Contents:

- temporal and spatial coherence, correlation function, degree of coherence
- laser medium: types of atomic bonds, energy levels, Boltzmann statistics, sponatneous emission, absorption, stimulated emission, inversion, 3- and 4-level laser systems, quasi-2-level systems, rate equations
- laser resonator: diffraction, Fresnel-number, lateral modes as eigenvalues of the resonator, mathematical description of the gaussmode, axial mode frequency, axial mode separation, axial mode bandwidth, resonance characteristics of the resonator seen as a Fabry Perot interferometer with loss, Q-factor, different types of resonators, g-parameter, regions of stability, stability diagram
- beam propagation: beam quality, matrix optics and ABCD-law for Gaussian beams, transition from Gauss to Airy distribution
- characteristics and applications of: CO2-lasers, Nd:YAG lasers, excimer lasers, diode lasers, pulse lasers, especially fs-lasers.

M: Microscopy

Professor, Unit shortcut, and Unit name: **E - W**
Altmeyer, M, Microscopy
(German name: Mikroskopie)

Pre-requisites:
MA1, MA2, PH1, PH2, GE1, GE2, OT1, OT2
Higher mathematics, basic knowledge in physics, deeper knowledge of: electrodynamics, beam optics and wave optics

Learning goals:

In general:
- Concepts of modern imaging technologies and their theoretical foundations, overcoming the limits of classical microscopy, practical experience with modern microscopes.

Know-how/methods/learning/social competence:
- The module is thought to deepen the knowledge in the theoretical backgrounds of imaging technologies. The additional mandatory practical training gives a strong link to real life applications and problems. Additionally the hands on experiments provide an ease of handling of high end microscopy equipment.

Professional preparation:
- Students are to comprehend, that constructs of ideas, which are difficult to understand at a first glance, are ubiquitous in today's technical products. Therefore the related ultimate principles have to be understood as a conditio sine qua non. The additional hands on experiences with such high end equipment dispells existing reservations.

Contents:
- Scanning electron microscopy: wave-particle dualism ; de Broglie wavelength ; relativistic mass ; resolution of electron-optics ; depth of focus in an electron microscope ; physics of electron emission: thermoionic emission, Schottky emission and field emission ; technical configuration and specifics of thermoionic-, Schottky- and field-emitters ; brightness as the conservative of a beam ; electric and magnetic lenses and equations of motion for electrons in them ; distortions and their minimation in electron optics ; principles of electron beam lithography ; Interaction of fast electrons with matter: bach scattered electrons, secondary electrons, Auger electrons, bremsstrahlung, characteristic x-rays and cathodoluminecence ; principles of imaging on the basis of the named types of interactions ; topography-, material-, lattice-orientation- and conductivity contrast
- Phase Microscopy: amplitude objects, Lambert’s law, phase objects, Abbe’s theory of imaging, phase relations in the different diffraction orders for amplitude and phase objects, phase shift arrangements: small disk and Zernicke-ring, Calculation of the contrast function for a Zernicke phase microscope.
- Interference Microscopy: Spatial and temporal coherence, interference, for Mach-Zehnder interferometer and Michelson interferometer: equal optical paths, compensation plates, phase lepas, complementarity of the interference patterns, requirements on coherence ; Interference Microscopy setups according to Linnik, Michelson and Mirau ; Shearing and Differential Interference Contrast (DIC) systems, multiple beam interference and Tolansky systems
- Confocal microscopy: confocal principle ; point spread function ; transition from Gauss to Airy distribution; pupil illumination and lateral resolution, confocal pinhole and depth discrimination

MA1: Mathematics 1

Professor, Unit shortcut, and Unit name: Knospe / Bold / Stoffel, MA1, Mathematics 1 (German name: Mathematik 1)	**C - W**
Pre-requisites: High school mathematics	
Learning goals: To impart fundamental mathematical knowledge about Calculus and Linear Algebra.	

Contents:

- Fundamentals about sets and mappings
- Natural, integer, rational, real numbers, fields
- Divisibility, residue classes, finite fields
- Propositional logic
- Equations, inequations and their solutions
- Real functions and their properties
- Injective, surjective, bijective, inverse functions
- Polynomials
- Rational -, trigonometric -, power -, root -, exponential -, logarithmic functions

- Limits and continuity
- Differential calculus: derivative, differentiation formulas
- Monotony, max-min problems
- L'Hospital's rule
- Tangents, Taylor polynomials, Taylor series
- Newton's method

- Vectors and vector spaces over fields
- Scalar product, norm, angle, orthogonality, vector product
- Plane geometry, lines, planes
- Matrices, matrix operations
- Systems of linear equations, Gaussian elimination (over arbitrary fields)

MA2: Mathematics 2

Professor, Unit shortcut, and Unit name:	C - S
Knospe / Bold / Stoffel, MA2, Mathematics 2 (German name: Mathematik 2)	

Pre-requisites:
MA1

Learning goals:
To impart fundamental mathematical knowledge about Calculus and Linear Algebra.

Contents:

- Complex numbers, cartesian form, polar form
- Roots and powers of complex numbers
- Euler relationship, complex exponential

- Riemann integral
- Fundamental theorem of calculus
- Definitive and indefinitive integral
- Integration of elementary functions
- Techniques of integration
- Complex integration

- Linear differential equations with constant coefficients

- Functions of several real variables
- Partial derivatives, gradient, tangent plane

- Linear mappings (over arbitrary fields) and their matrices
- Matrices, determinants, Laplace expansion
- Cramer's rule
- Inverse matrix
- Eigenvalues and eigenvectors
- Linear (in-)dependence, basis, coordinates, dimension
- Symmetric, orthogonal matrices
- Change of basis

MC1: Material Science and Chemistry 1

Professor, Unit shortcut, and Unit name: **?? - S**
Welker, MC1, Material Science and Chemistry 1
(German name: Werkstoffkunde und Chemie 1)

Pre-requisites:
MA1, MA2, PH1, PH2, GE1, GE2

Learning goals:
- Basic knowledge of material science: structure of materials, electronic, magnetic, dielectric and optical properties
- Because many excellent books and a lot of literature are available for material science, students have to learn using secondary literature to study in this course.
- Without knowledge of too much details, the students learn to understand structure and properties of materials from the electronic properties of atoms.

Contents:
- Atomic model, distribution of electrons in an atom, periodic table of elements, chemical bonding and crystal structures.
- Electronic properties of metals (Drude theory)
- Semiconductors (band structure, intrinsic- and defect conductivity , pn-transition),
- Dielectrics (dielectric classes, dielectric polarization and loss. optical properties on base of Lorenz-oscillators, comparison ε_1, ε_2 versus n,k description)
- Magnetic materials (magnetic classes, magnetization, hysteresis curve, loss mechanism)

MC2: Material Science and Chemistry 2

Professor, Unit shortcut, and Unit name: **?? - W**
Löbach, MC2, Material Science and Chemistry 2
(German name: Werkstoffkunde und Chemie 2)

Pre-requisites:
The lectures in chemistry will be held for beginners. There is no need for previous knowledge

Learning goals:
- Knowledge of the basic and the mean reactions both in organic and inorganic chemistry.
- Knowledge of the basic concepts in physical chemistry.

Contents:
- Inorganic Chemistry: the mass action law, the calculation of the mass action constant, oxidation and reduction, definition of acids and bases, some important acids and bases, combined reactions from acids/bases and oxidation materials or reduction materials, the Nernst Equation, electrochemical fuel cells
- Organic Chemistry: Carbohydrates with saturated or unsaturated bonds, aromatic hydrocarbons, functional groups like alcohols, amines or organic acids, carbonyl compounds like ketones or aldehydes,
- Organic reactions: esterification, electrophilic addition to multiple bonds
- Polymer chemistry: some basic polymers for use in microlithography

MDT: Advanced Display Techniques

Professor, Unit shortcut, and Unit name: Eg - **S**
Schwedes, MDT, Advanced Display Techniques
(German name: Moderne Displaytechniken)

Pre-requisites:
Bachelor electrical engineering or Bachelor Information Engineering

Learning goals:
The advanced display technologies are understood, comparison of the different techniques can be done, estimation of future developments is possible

Contents:
- Short introduction to working principle and parameters of displays:
  - the human eye, addressing, excitation, el.-opt. effect
  - demands on high informative displays: non linear el.-opt. characteristic, short switching time, memory effect, high el.-opt. efficacy
- advanced display techniques:
  - LCD: fundamentals of birefringence, vertical alignment, in plane switching
  - PDP, EL: advantage of ac-addressing, current limiting processes, voltage transfer curve
  - TV – Microdisplays: current technologies and further developments
  - OLED, E-Paper: functional principle, possibility of full plastic displays, OLED (self emitting, current controlled) – E-Paper (light modulating, field controlled)
  - 3D-Displays: stereoscopic vision, used principles
  - Large area cold cathode: cathodoluminescence, principles of electron emission, carbon nano tubes, Spindt, SED
  - Organic electronics: parameter of used materials, comparison with Si-technology, application in displays

MK: Mobile Communications

Professor, Unit shortcut, and Unit name: E - **S**

Dettmar, MK, Mobile Communications
(German name: Mobilkommunikation)

Pre-requisites:

- Basic knowledge on digital communications
- ISO/OSI model and terminologies
- Basic knowledge on layer 1 and 2 protocols

Learning goals:

General:

- gain knowledge on basic principles of mobile communications
- get in touch with actual and future standards on mobile communications

Module-specific:

- students will know about specifics on radio channels and related transmission methods
- they will know about the related protocols
- they will know about the fundamentals of cellular networks
- they will know about the fundamentals on mobile MAC
- they will know basics of the GSM/GPRS standard
- they will know basics of UMTS
- they will know basics of WLAN and PAN communications

Know-how/methods/learning/social competence:

- they will be able to read and interpret message charts
- they will be able to understand architectures of mobile transmission systems
- they will be able to determine achievable data rates
- they will be able to design applications on mobile communication platforms
- they will be confronted with English language text books.

Professional preparation:

- students know basics on actual mobile standards and can estimate their usability for user defined applications
- they learn basics on project management and processing during a complement project work

Contents:

- Cellular networks
- Mobile radio channels and transmission principles
- System examples
  - GSM/GPRS
  - UMTS
  - IEEE802.11
  - Bluetooth

MMC: Multimedia Communications

Professor, Unit shortcut, and Unit name: Eg - **S**
Grebe, MMC, Multimedia Communications
(German name: Multimediakommunikation)

Pre-requisites:
Successfully completed Bachelor studies in informatics or electrical engineering (information technologies or communication technologies). Basic knowledge on computer networks or telecommunication networks, and TCP/IP protocol family. Fundamental knowledge in design and operation of computers and operating systems, experiences in OS (Linux preferred), programming skills (C, C++, or Java).

Learning goals:
In general & Module-specific:
- Fundamental knowledge on multimedia support in networks.
- Knowledge on characteristics and requirements of IP-based multimedia services (voice, video) and several actual encoding algorithms.
- Knowledge on QoS requirements and QoS support technologies.
- Knowledge on modelling and performance evaluation of communication networks.
- Knowledge on performance evaluation of queuing algorithms to provide QoS.

Know-how/methods/learning/social competence & Professional preparation:
- Students will be able to analyse and evaluate network architectures for multimedia services.
- Students will be able to carry out performance evaluations of networking devices and complete networks.
- Students will be able to find concept and protocol weaknesses by intensive protocol analysis and functional testing.
- Students are training their English skills with English textbook, original standards and applications descriptions.

Contents:
- Requirements and design of multi-service networks, multimedia service requirements, Voice-over-IP (VoIP) and Video-over-IP services, integration of IP streaming and data services, audio coding algorithms, video coding algorithms, introduction to IP TV
- Multi-service network architectures, roll-out of multi-service networks, network architectures, multi-service network elements (ingress router, egress router, core router), call admission control (CAC), resource and admission control function (RACF), network access configuration function (NACF)
- Quality-of-Service (QoS) mechanisms, IntServ, DiffServ call-of-service concepts, expedited forwarding, assured forwarding, best effort, queuing algorithms, DiffServ domains, per-hop-behaviour, per-domain-behaviour, inter-domain behaviour, priority queuing, custom queuing, class based queuing, fair queuing, weighted fair queuing, class based weighted fair queuing, QoS signalling.
- Traffic modelling and performance analysis, fundamentals of stochastic processes, renewal processes, Poisson processes, discrete time Markov chains continuous time Markov chains, introduction to queuing theory, single-server queuing systems, queuing networks, simulation of queuing systems

MRT: Measurement and Control Technique

Professor, Unit shortcut, and Unit name: Nachtigall, MRT, Measurement and Control Technique (German name: Mess- und Regelungstechnik)	**C - S**
Pre-requisites: MT, PH1, PH3, MA1 Error propagation. Error calculation, error consideration, static and dynamic behaviour of measurement equipment, measurement of current and voltage, measurement of resistances, electromechanic measurement movements, bridge circuits, fundamentals in electrotechnique and physics, thermodynamic and fields, differential and integral calculation	
Learning goals: ➢ students will gather knowledge on fundamentals of measuring and control technique ➢ they learn to use measuring tools for power engineering ➢ they will know about the measurement of idle power, active power and apparent power ➢ they know how to use sensors for special applications in high power engineering ➢ they will understand the fundamentals of control circuits	
Contents: ➢ Measurement of idle power, active power and apparent power taking into account the standards ➢ Tools for measuring in high current and high voltage plants ➢ Sensors in high energy environment ➢ Fundamentals of control technique	

MT: Measurement Technique

Professor, Unit shortcut, and Unit name: **C - W**
Nachtigall, MT, Measurement Technique
(German name: Messtechnik)

Pre-requisites:
GE1, MA1
Current, calculation of linear networks, electrostatic field, magnetic field, magnetic circuit, non linear networks, introduction to alternating current, differential and integral calculation

Learning goals:
- students will gather knowledge on fundamentals of theory and application in measurement technique
- they will know about the calculation of linear networks
- they will be able to make differential calculation of transient occurrences
- they will be able to estimate error sources and to compensate them
- they will know about measuring methods for loadless measuring of the sensor signal
- they will be able to choose the correct analogue measurement equipment
- they will know about the application of measuring amplifier
- they will be able to decide about the correct sensors

Contents:
- error consideration, statistical and systematic
- error propagation
- analogue movements
- measurement of voltage and current
- sensors which produce voltage or current
- bridge circuits for the ohmic and complex resistances
- sensors which change resistance value
- sensors which change inductance or capacitance value

MT1: Measurement Technology 1

Professor, Unit shortcut, and Unit name: Silverberg, MT1, Measurement Technology 1 (German name: Messtechnik 1)	**E - W**
Pre-requisites: MA1, MA2, GE1, GE2 Integrals; derivatives; trigonometric, exponential and logarithmic functions; limits; series; partial fractions expansion; complex numbers; Fourier series; R-, L-, and C-circuits	
Learning goals: Students will gather fundamental knowledge in measuring of analogue and digital signals and measurement applications.	
Contents: ➢ SI-System ➢ Fundamentals in electrical measurement technology ➢ Fundamentals in statistical data processing ➢ Analogue Multimeters ➢ Digital Multimeters ➢ Analogue and sampling scopes ➢ Frequency measurement ➢ Spectrum analysis	

MThK: Master Thesis (Communication Systems and Networks)

Professor, Unit shortcut, and Unit name: all involved faculty; representative: Prof. Pörschmann (German name: Messtechnik 1)	**C - W,S**
Pre-requisites:	
Learning goals: The Master Thesis forms an independent scientific work. The students learn to work on a given topic in a given time. They learn to describe the technical and scientific background of their work and to combine the details with interdisciplinary knowledge. The Master Thesis gives the students the possibility to enhance the knowledge on one specific topic.	
Contents: The Master Thesis usually confronts the student with a task which is either experimental, design-orientated, theoretical or guided by another typical engineering task. The students are asked to find a straightforward solution to the given problem. The topic is supervised by one of the professors and is typically taken from his actual research topics. Alternatively the master thesis can cover topics from cooperations with companies or with other scientific research institutes.	

MU1: Measurements and Signal Processing

Professor, Unit shortcut, and Unit name: **E - W**
Stoll, MU1, Measurements and Signal Processing
(German name: Messsignalverarbeitung)

Pre-requisites:
IN1, IN2, MA1, MA2, GE1, GE2, EL1, EL2, MS, ASS
Programming languages; electrical components; Fourier transform; description of systems in the frequency domain

Learning goals:

In general:
- students will gather knowledge on choice, development, optimization, and application of devices/equipment and facilities for electrical measurements of variables in the industry and plants

Module-specific:
- students will learn about analog and digital processing of measurement signals
- they will learn about electrical measurement techniques and precision circuits for transmitters
- they will work with computer based measurement signal logging and processing (in PC, micro-controller, Digital Signalprocessor and Embedded Systems)

Know-how/methods/learning/social competence:
- students will be able to realize and solve problems of measurements with linear and non-linear amplifiers working under the influence of disturbance variables in industrial environment.
- they will optimize the systems regarding economical aspects
- they will learn about synthesis of precision circuits
- they will choose and realize adequate method of measurement signal acquisition and processing

Professional preparation:
- students learn about the automation of measurements in the industry
- they work on practical examples and get to know professional experiences (also of students who worked before their studies)
- they will work on industrial measurement equipment
- they will discuss innovations

Contents:
- industrial measurement chain
- properties/characteristics of a measurement facility
- errors and disturbance variables
- real operational, differential and instrumentation amplifiers
- data acquisition, interfaces
- non-linear, analog measurement signal processing
- algorithms of digital measurement signal processing
- use of measurement application software, virtual instruments

MU2: Sensorics

Professor, Unit shortcut, and Unit name:	E - S
Stoll, MU2, Sensorics (German name: Sensortechnik)	

Pre-requisites:
PH1, GE1, GE2, EL1, EL2?, MS, MS2?
Physics; electrical engineering; electronics; measurement technology

Learning goals:

In general:
- students will gather knowledge on choice, development, application, and optimization of sensors and measurement devices/equipment

Module-specific:
- students will learn about the most important principles and procedures of electrical measurement of non-electrical variables in the industry

Know-how/methods/learning/social competence:
- students will be able to realize the requirements in a sensor
- they will learn to choose the appropriate measurement principle and sensor type
- they will learn to evaluate advantages and disadvantages

Professional preparation:
- students learn about the automation of measurements in the industry and plants
- they work on practical examples and get to know professional experiences (also of students who worked before their studies)
- they will work on industrial measurement equipment
- they will discuss innovations

Contents:
- measurement variables: position, strain, stress, extension, force, pressure, revolution, oscillation, flow, level, temperature, moisture, radiation, concentration, pH-value
- sensors based upon: resistance, capacitance, inductance, thermocouple, galvanic couple, induction, current, charge, optical and acoustic waves, thermal effects, mechanical resonators

NGN: Next Generation Networks

Professor, Unit shortcut, and Unit name: Grebe, NGN, Next Generation Networks (German name: Next Generation Networks)	**Cg - W**

Pre-requisites:
Successfully completed Bachelor studies in informatics or electrical engineering (information technologies or communication technologies). Basic knowledge on computer networks or telecommunication networks, and TCP/IP protocol family. Fundamental knowledge in design and operation of computers and operating systems, experiences in OS (Linux preferred), programming skills (C, C++, or Java)

Learning goals:
In general & Module-specific:
- Fundamental understanding of NGN network concepts, network technologies and multimedia service delivery protocols.
- In depth knowledge of the NGN network functions and network elements.
- Knowledge on the interaction between transmission networks, network layer, transport protocols, QoS requirements and QoS support technologies, and service delivery signalling in the IP domain.
- In depth knowledge on the SIP/SDP signalling concepts, protocols, and interdependencies.
- Knowledge on the migration of legacy telecommunication networks (GSM, UMTS, ISDN) and data networks (Internet, LAN, WLAN) to NGN.

Know-how/methods/learning/social competence & Professional preparation:
- Students will be able to analyse and evaluate services and network requirements for NGNs.
- Students will be able to design network concepts with appropriate QoS mechanisms for NGN.
- Students will be able to setup VoIP services in IP networks for enterprises and carriers.
- Students will be able to find concept and protocol weaknesses by intensive protocol analysis and functional testing.
- Students are training their English skills with English textbook, original standards and applications descriptions.

Contents:
- Introduction to NGN, requirements for NGN, evolution of all-IP-networks, NGN concepts and architectures, protocols, services, standardisation of NGN (IETF, 3GPP, ETSI TISPAN)
- Multimedia services in NGN, service requirements, integration of streaming (voice, video) and data services, introduction to Voice-over-IP (VoIP), introduction to Video-over-IP, transport of streaming services, RTP, RTCP.
- Quality-of-Service (QoS) in NGN in different network layers, IntServ, resource reservation protocol (RSVP), DiffServ class-of-service concepts, queuing mechanisms, multiprotocol label switching (MPLS), asynchronous transfer mode (ATM)
- Signalling in NGN, SIP (Session Initiation Protocol), SDP (Session Description Protocol), SIP service elements, comparison to H.323 protocol family, signalling with Network Address Translation (NAT and NAPT), symmetric response routing (SRR), simple traversal of UDP through NAT (STUN).
- Media gateway concepts, gateway protocols (MGCP, MEGACO), SIP/H.323 gateway, SIP/ISDN gateway, SIP/SS#7 gateway, Session Border Controller (SBC)
- Fixed Mobile Convergence (FMC), architectures of fixed telecommunications networks (ISDN, SS#7), architectures of mobile networks (GSM, UMTS), IP Multimedia Subsystem (IMS) architecture and concepts, NGN architecture of ETSI TISPAN, examples of converged networks
- Special services in NGN, authentication, authorisation, accounting (AAA), introduction to DIAMETER, mobility in NGN (Mobile IP), Location Based Services (LBS), Peer-to-Peer Services

NP: Networks and Protocols

Professor, Unit shortcut, and Unit name: **C - W**
Grebe, NP, Networks and Protocols
(German name: Netze und Protokolle)

Pre-requisites:
Boole's Algebra, fundamental knowledge in design and operation of computers and operating systems, experiences in OS (Linux preferred), programming skills (C, C++, or Java)

Learning goals:
In general & Module-specific:

- Fundamental understanding of networking concepts, layered network models and protocols
- Knowledge on major standardisation organisation and processes including accessibility of standards on computer networks (IEEE standards), the TCP/IP protocol family (IETF RFC), telecommunications (ITU-T, ETSI) and mobile networks (3GPP).
- Knowledge on different network architecture and differentiation of telecommunication networks, mobile networks, enterprise networks, and the Internet.
- Knowledge on network elements and functions, especially the functionality of NIC, Hub, Switch, Router and Application Server.
- Knowledge of IP networking and routing, network application protocols, and LAN protocols
- Fundamental knowledge of information theory, and transmission technologies.

Know-how/methods/learning/social competence & Professional preparation:

- Students will be able to design and configure IP networks including sub netting.
- Students will be able to perform intensive network testing and fault inspections.
- Students will be able to perform intensive protocol analysis including functional testing and performance analysis.
- Students will be able to design and setup IP networks for small and medium enterprises.
- Students are training their English skills with original standards and applications descriptions.

Contents:

- Introduction to computer networks, requirements, development of network technologies, applications, network topologies, characterisation of networks, switching technologies, connection orientation
- Communication models, layered model of networking tasks, protocols, ISO-OSI reference model, TCP/IP model, IEEE LAN model, introduction to protocol design.
- Network architectures, comparison of telecommunication networks (ISDN), mobile networks (GSM, UMTS), enterprise networks (LAN, WAN), and the Internet.
- Application protocols, file transfer, FTP, TFTP, Terminal services (Telnet, SSH), Email services (SMTP), Web services (HTTP, HTTPS), Domain Name Service (DNS)
- Transport protocols, transport services and service classes, UDP (transport multiplex), TCP (assured transport service), transition state based protocol engines, TCP flow control, congestion control, TCP timing control
- Network layer technologies, switching services, connection orientation, addressing, internetworking, Internet Protocol, IP addressing (IPv4), routing, ARP, DHCP, routing protocols (distance vector RIP, link state OSPF), interdomain routing (BGP), IPv6
- Data link layer technologies, framing, ARQ mechanisms, media access control, LAN protocols and performance, Ethernet variants, LAN bridging and switching, spanning-tree-algorithm
- Refresher on transmission technologies, fundamentals of information theory, transmission media, modulation, line coding, synchronisation, multiplexing, channel coding, error detection technologies, CRC, source coding

NWS: Network Security

Professor, Unit shortcut, and Unit name: Leischner (FH BRS), NWS, Network Security (German name: Sicherheit in Netzen)	Eg - W
Pre-requisites: HLP, KRY, NGN	
Learning goals: ➢	
Contents: ➢ Attacks, weak points, protection goals ➢ Design, analysis and methods for secure network protocols ➢ Protocols for netwok security ➢ Secure E-business communication ➢ Authentication, autorization, access control ➢ Selected protocols on application layer ➢ Security architectures	

OBE: Optoelectronic Components

Professor, Unit shortcut, and Unit name: Eg - **S**
Welker, OBE: Optoelectronic Components
(German name: Optoelektronische Bauelemente)

Pre-requisites:
PH1, PH2 EL1, EL2, WK
Fundamentals in physics, advanced knowledge in electronics and material sciences

Learning goals:

In general:
- Students will learn fundamentals about optoelectronic components.
- Main emphasis is put on material and structures of LEDs, Diode Lasers and Detectors.

Module-specific:
- Students will learn the selection of optical emitter and detectors for different applications

Know-how/methods learning/social competence:
- Students will learn theoretical knowledge in small seminar groups
- They will train the practical applications of their knowledge in experimental projects
- They will work in teams simulating the tasks of development division/department

Professional preparation:
- Students learn to plan a project and to realize it in laboratories of the institute
- They document and vindicate the results in their teams

Contents:
- Light absorption in solids, density of electronic state and occupation properbility, fermi energy, work function
- Electrical conductivity, pn-junction, hetero structures, band gap engineering

- Emitters: LEDs, diode lasers, OLEDs, thin film and thick film electroluminescent devices
- Detectors: quantum and thermal detectors

OM2: Optical Measurement 2

Professor, Unit shortcut, and Unit name: Kraus, OM2, Optical Measurement 2 (German name: Optische Messtechnik 2)	**?? - ??**

Pre-requisites:
MA1, MA2, GO, WO,OM 2
Integrals; Derivatives; trigonometric, exponential, limits; series; complex numbers; Fourier series; geometrical optics

Learning goals:

In general:
- the students learn to solve optical problems on their own

Module-specific:
- they work on little projects. students have to organize the experiment by themselves
- they will do the project management, including project draft, milestones and final presentation

Know-how/methods/learning/social competence:
- they learn to simulate the experiment with a computer
- they will split the experiment in to small portions for a better control of the different parameters
- they will use data acquisition hard- and software

Professional preparation:
- they will learn to solve a given problem and to do the time management

Contents:
- measurement of optical and non optical features using optical methods
- simulation of the problem using a computer
- data acquisition with a computer
- special aspects of geometrical optics for optical measurement
- special aspects of wave optics for optical measurement
- todays applications in optical measurement
- project management
- presentation of experimental results

OMT: Optical Measurement

Professor, Unit shortcut, and Unit name: Kraus (NF Gutjahr), OMT, Optical Measurement (German name: Optische Messtechnik 1)	E - **S**
Pre-requisites: MA1, MA2, GO, WO Integrals; Derivatives; trigonometric, exponential, limits; series; complex numbers; Fourier series; geometrical optics	
Learning goals: In general: ➢ the students learn to solve problems by using optical methods Module-specific: ➢ they learn the theory of light detectors and how to use them for practical work ➢ they will know, which detector is suitable for the given problem (speed, sensitivity, spectral response, noise...) Know-how/methods/learning/social competence: ➢ they will know to use spectrometers for various applications ➢ they will learn to use digital cameras for making optical measurements ➢ they will learn to use different kinds of interferometers Professional preparation: ➢ they will have practical experience in many fields of optical measurement	
Contents: ➢ sensors for electromagnetic radiation (light) ➢ opto electrical conversion ➢ properties of different sensors (sensitivity, detectivity, noise, signal to noise, dark signal, spectral response ....) ➢ application and programming of CCD cameras for different measuring setups ➢ spectrometers, resolution, calibration and applications ➢ light sources, properties, applications ➢ overview on today applications of optical measurement	

ON: Optical Communications

Professor, Unit shortcut, and Unit name: Reidenbach, ON, Optical Communications (German name: Optische Nachrichtentechnik)	E - ??

Pre-requisites:
Physics; fundamentals in electrical engineering; physics, especially optics
Assumed matters:
Fundamental knowledge in semiconductors e.g. electrons and holes, band structure, pn junction, doping, fundamentals of optics (reflection, refraction, transmission et al.), electrical and magnetic field, fundamentals on waves, fundamentals in optics

Learning goals:

In general and module-specific:

- The module presents the basics of semiconductor devices as sources for optical communications and the fundamentals of optical waveguides.

Know-how/methods/learning/social competence:
- The theoretical fundamentals and the know how in modern semiconductor technology, which are necessary for the realization of optoelectronic devices applied as sources in optical communication transmission networks, is presented.
- In addition the theoretical basics and the knowledge in modern optical waveguide technology is given in more detail.
- In the laboratory (practical course) the students get the knowledge how to measure laser parameters and use simple methods for beam diagnostics. In the 2nd part methods for the determination of transmission and attenuation characteristics of modern glass and polymer fibres are applied. State of the art measurement equipment is used.
- Actual topics in optical communications, especially in optoelectronics, will be presented by the participants and discussed in a seminar. In a 2nd seminar a strategic “role play” is implemented in the program dealing with a typical industrial project.

Professional preparation:
- The students become familiar with the especially important optical sources and will get the knowledge how to use such a device in modern optical communications. In addition optical waveguides are presented as the central part of a modern transmission network.
- Since the application of specific methods to measure optical characteristics of optical devices and waveguides is very important the students will receive the respective training in the lab courses.
- The presentation of worked out topics in a seminar and the supplementary discussion improves the know-how and the soft skills simultaneously.

Contents:
- Fundamentals in optoelectronics
- LEDs
- Laser diodes
- Design and specialties
- Geometrical optics, total internal reflection
- Fundamentals in waveguides, Maxwell theory
- Law of refraction and reflection, transmission and attenuation
- Materials for optical wave guides, especially glass and polymers
- Connectors and splices
- Integrated optics
- Detectors

OSA: Optical Spectroscopy and Applications

Professor, Unit shortcut, and Unit name: **Eg - S**
Gartz, OSA, Optical Spectroscopy and Applications
(German name: Optische Spektroskopie und Anwendungen)

Pre-requisites:
MA1, MA2, PH1, PH2
Higher mathematics, basic knowledge in physics, basic knowledge in optics

Learning goals:

In general:
- Students will gather knowledge about optical spectroscopy and spectrometer systems in theory.
- They will gather knowledge about construction and industrial applications of different spectrometers.

Module-specific:

Know-how/methods/learning/social competence:
- Students will be able to design a spectrometer for a given measurement task.
- They will be able to select the important components like diffractive optical element, detector, and imaging optics for a spectrometer system.
- They will be able to analyze problems out of the domain of optical spectroscopy.
- They will be able to apply the acquired attainments for the selection and application of different optical spectrometers to solve several optical assignments of tasks.

The additional mandatory project work complements the course.

Contents:
- Fundamentals of optical spectroscopy
- Path of rays of different spectrometers
- Resolution power of grating spectrometers and prism spectrometers
- Generalized resolution power
- Emission spectroscopy
- Absorption spectroscopy
- Construction of different spectrometers
- Negative effects in spectrometers like stray light, second order effects and ghost images
- Applications like layer thickness measurement, color measurement or determination of the refractive index

PD1: Process-Data Processing 1

Professor, Unit shortcut, and Unit name: **E - W**
Uerlings, PD1 Process-Data Processing 1
(German Name: Prozessdatenverarbeitung 1)

Pre-requisites:
none

Learning goals:

In general:
- methods for planning automation projects
- design, realization and functional principles of automation systems, in particular setup, implementation style and programming of real-time computers as well as their configuration and interaction with the technical process

Module specific:
- basics of real-time data-processing

Contents:
- basic technical terms of automation systems
- definitions
- classification of technical processes
- ways of coupling computers with technical processes
- adaptation of computer and technical process
- structure of a real-time computer
- data polling and interrupt based communication principles
- data flow
- control flow

PD2: Process-Data Processing 2

Professor, Unit shortcut, and Unit name: **E - S**
Uerlings, PD2, Process-Data Processing 2
(German Name: Prozessdatenverarbeitung 2)

Pre-requisites:
PD1

Learning goals:

In general:
- methods for planning automation projects
- design, realization and functional principles of automation systems, in particular setup, implementation style and programming of real-time computers as well as their configuration and interaction with the technical process

Module specific:
- application of methods of real-time data-processing

Contents:
- configuring host and run-time systems
- functional principles of real-time operating systems
- parallel operation, multitasking, time sharing
- asynchronous event driven programming
- semaphores

PH1: Physics 1

Professor, Unit shortcut, and Unit name: **C - W**
Steinbeck, PH1, Physics 1
(German name: Physik 1)

Pre-requisites:
- Module Mathematics 1
- Matriculation standard skills in physics and mathematics (e.g. basic arithmetic, algebra and geometry; trigonometric-, exponential- and logarithmic-functions; methods of calculus and vector algebra)

Learning goals:

In general:
- A broad background in classical physics is given in lectures, exercises and a mandatory laboratory, providing an introduction to physical phenomena and basic concepts as well as some necessary mathematical tools.

Module specific:
- The course covers mechanics of particles, rigid bodies, and fluids as well as thermodynamics.

Know-how/methods/learning/social competence:
- The emphasis will always be on understanding the fundamental principles, the connections between phenomena and the basic concepts and methods in formulating and solving problems in physics and engineering.

Professional preparation:
- Physics and physical laws and concepts underlie the engineering sciences and underpin most aspects of modern technology. Knowledge of physics is therefore vital in understanding latest scientific findings and in successfully realizing new technological applications.

Other:
- Physics and mathematics are exquisitely powerful intellectual tools that provide useful knowledge without there is no education, especially no engineering education.

Contents:
- **Introduction**: Physical Quantities, Standards, and Units; Calculation of Errors.
- **Kinematics**: Motion in 1, 2 and 3 Dimensions; Circular Motion; Oscillations.
- **Dynamics**: Basic Laws of Motion; Relative Motion; Work, Energy, and Power; Translation and Rotation; Conservation of Energy and of Linear and Angular Momentum.
- **Gravitation**; Elasticity; Ideal Fluids at Rest and in Motion; Special Relativity.
- **Thermodynamics**: Temperature, 0th Law of Thermodynamics, and Thermal Equilibrium; Thermal Expansion; Kinetic Theory and Equation of State of Ideal Gases; Real Gases, Liquids, and Solids; Heat and Heat Measurement; 1st and 2nd Law of Thermodynamics; Heat Transfer.

Physics underpins most aspects of modern technology and medicine, and developments in physics often drive social change. Two examples include the development of electromagnetic wave theory, which led to electric power, radio and television; and atomic physics, which resulted in electronics, microchips and computers, nuclear medicine and radiation treatment of cancers. This course provides an overview of topics in physics that are of particular importance to life and medical sciences and aspects of engineering. The course is non-calculus based and covers mechanics (motion, friction, work, energy), electricity and magnetism, heat, nuclear and radiation physics, fluid mechanics, and waves.

PH1: Physics 1

Professor, Unit shortcut, and Unit name: Schwedes, PH1, Physics 1 (German name: Physik 1)	**C - W**
Pre-requisites: Mathematics: differentiation, integration, trigonometric functions	
Learning goals: Description of different physical phenomena is known: ➢ kinematic and dynamic description of motion ➢ effect of forces ➢ Interaction of Particles (from Atoms to Macroscopic Bodies) ➢ Work and energy (types of energy) ➢ description of a system by forces or energies ➢ quantities of conservation	
Contents: ➢ Introduction: Physical Quantities, Units ➢ Mechanics: Kinematics: basic quantities, types of motion (in one and three dimensions), vector Dynamics: Newton`s laws, force, inertial frame, work, energy, impact, momentum, laws of conservation, Gravitation, Elasticity, static and flowing material, Bernoulli`s equation ➢ Thermodynamic: Kinetic theory of gas; thermal expansion; Laws of thermodynamics; ideal gas	

PH2: Physics 2

Professor, Unit shortcut, and Unit name: **C - S**
Steinbeck, PH2, Physics 2
(German name: Physik 2)

Pre-requisites:
- Modules: Physics 1; Mathematics 1; Mathematics 2
- Standard skills in physics 1 and mathematics 1 and 2 (e.g. basic arithmetic, algebra and geometry; trigonometric-, exponential- and logarithmic-functions; methods of calculus and vector algebra; complex numbers; ordinary differential equations)

Learning goals:

In general:
- A broad background in classical physics is given in lectures, exercises and a mandatory laboratory, providing an introduction to physical phenomena and basic concepts as well as some necessary mathematical tools.

Module specific:
- The course covers electricity and magnetism, oscillations and waves, and optics.

Know-how/methods/learning/social competence:
- The emphasis will always be on understanding the fundamental principles, the connections between phenomena and the basic concepts and methods in formulating and solving problems in physics and engineering.

Professional preparation:
- Physics and physical laws and concepts underlie the engineering sciences and underpin most aspects of modern technology. Knowledge of physics is therefore vital in understanding latest scientific findings and in successfully realizing new technological applications.

Other:
- Physics and mathematics are exquisitely powerful intellectual tools that provide useful knowledge without there is no education, especially no engineering education.

Contents:
- **Electrostatics**: Electric Charge and Coulomb's Law; Electric Field and Electric Potential; Gauss' Law; Energy Stored in an Electric Field; Dielectrics.
- **Electric Currents**: Current and Current Density; Ohm's Law; Work, Energy, and Emf; Electrical Conductivity.
- **Magnetostatics**: Magnetic Field; Magnetic Force on Moving Charged Particles and on Current-Carrying Wires; Ampere's Law; Dia-, Para-, and Ferromagnetism.
- **Electromagnetism**: Faraday's Law of Induction; Self-Induction; Energy Stored in a Magnetic Field; Maxwell's Equations.
- **Oscillations**: Free and Damped Harmonic Oscillations; Forced Harmonic Oscillations; Superposition of Oscillations; Coupled Oscillations.
- **Waves**: Wave Equation and Types of Waves; Propagation of Waves; Superposition of Waves and Interference; Standing Waves.
- **Optics**: Reflection and Refraction at Plane and Spherical Surfaces; Images; Optical Instruments; Interference; Diffraction; Polarization.

PH2: Physics 2

Professor, Unit shortcut, and Unit name:	C - S
Schwedes, PH2, Physics 2 (German name: Physik 2)	
Pre-requisities: Modules: Physics 1, Mathematics 1 Mathematics: ordinary differential equations Basic knowledge about electrical engineering	
Learning goals: Basic physical concepts are known: ➢ Electrical and magnetical field ➢ Periodical processes ➢ Propagation of waves ➢ Analogies of description	
Contents: Oscillation: ➢ Spring oscillation; simple pendulum; attenuation; resonance; interference; beat; coupled oscillators Waves: ➢ Propagation; interference; stationary wave; Doppler effect; interaction on surface Optics: ➢ Huygens` principle; reflection; refraction, diffraction ➢ Geometrical optics; lenses, wave optics; thin layers Thermodynamics: ➢ Temperature; kinetic gas theory; heat expansion; ideal gas; laws of thermodynamics; Electrostatic: ➢ Charge; Coulomb force; electric field; electrical potential; displacement density; energy of electric field Electrodynamic: ➢ Charge transport; current; resistor; Ohm`s law; Kirchhoff`s laws; interaction of charge and el. field: capacity; magnetic field; energy of magnetic field; induction, Lorentz force, resonant circuit ➢ Gauß` law; Ampere`s law; law of induction Fundamentals of modern Physics: ➢ Atomic model; quantum mechanics; probability statement; indeterminacy principle	

PI1: Practical Informatics 1

Professor, Unit shortcut, and Unit name: **C - W**
Vogt / Büchel / Rosenthal, PI1, Practical Informatics 1
(German name: Praktische Informatik 1)

Pre-requisites:
none

Learning goals:
- Learn about fundamental concepts and techniques of Practical Informatics.
- Learn to solve small-size application problems algorithmically.
- Write programs in an object-oriented language (i.e. Java).

Contents:
- Operation principle of a digital computer.
- Algorithms and programs.
- Scalar and structured data types in Java.
- Control structures in Java.
- Methods in Java.
- Objects, classes, and class hierarchies in Java.

PI2: Practical Informatics 2

Professor, Unit shortcut, and Unit name: **C - S**
Vogt / Büchel / Rosenthal, PI2, Practical Informatics 2
(German name: Praktische Informatik 2)

Pre-requisites:
Practical Informatics 1.

Learning goals:
- Learn about fundamental concepts and techniques of Practical Informatics.
- Learn to solve small-size application problems algorithmically.
- Write programs in an object-oriented language (i.e. Java).

Contents:
- Programming with Java class hierarchies and standard packages.
- Formal specification of syntactical structures.
- Exception handling in Java.
- Graphical user interfaces in Java.
- Basic concepts of UML.
- Dynamic data structures, graphs.

PLS: Enterprise Resource Planning

Professor, Unit shortcut, and Unit name: **E - W,S**
Schellong, PLS, Enterprise Resource Planning
(German name: Produktionsleitsysteme)

Pre-requisites:
MA1, MA2, GE1, GE2, IN1, IN2
differential and integral calculus, algorithms, basics in software engineering

Learning goals:

In general:
- students will gather knowledge on **computer aided enterprise resource planning** including application in energy economy

Module-specific:
- students will know about the mathematical tools of modelling and data analysis of production systems
- they will know about the necessary informational technologies to built up a planning system
- they will know about the goals and structure of process information management systems
- they will know about the goals and structure of energy management systems
- they will know the methods for the forecast of the energy demand
- they will know the necessary integration of different information systems in planning process
- they will know optimization strategies

Know-how/methods/learning/social competence:
- students will be able to apply the mathematical and informational tools for enterprise resource planning
- they will be able to analyze the technical, economical and informational framework conditions of energy supply
- they will learn the interdisciplinary character of applied project work
- they will be able to work in a project team
- they will be able to represent their results by computer aided presentations

Professional preparation:
- students can work on actual problems of energy economy
- they have learned to apply combined methods for modeling and optimizing technical and economical energy systems

Contents:
- information systems in the different enterprise levels
- data analysis, data flow, data structure
- enterprise-resource-planning-systems (ERP)
- process information management systems (PIMS)
- resource planning in the energy economy
- objectives and structure of energy management systems
- forecast of energy demand (regression models and artificial neural networks)
- project management

PLT1: Process Control Engineering 1

Professor, Unit shortcut, and Unit name: **C - W**
Große, PLT1, Process Control Engineering 1
(German name: Prozessleittechnik 1)

Pre-requisites:

Learning goals:

In general:
- Students will gather knowledge in project management of automation engineering projects. This contains current standard techniques in engineering of DCS (distributed control systems), programming PLCs (programmable logic controllers), the knowledge of sensors for non-electric process variables and actors.

Module-specific:
- Project Management, DCS, sensor technology, calculating valves, field busses

Know-how/methods/learning/social competence:
- Students will learn to work in teams
- Multimedia presentation of results of teamwork
- Training to represent an enterprise
- Development of solution strategies

Professional preparation:
- Preparation of the complete corporate planning documents
- Teamwork
- Presentation skills
- Written skills

Contents:
- Phase diagrams
- Entity relationship models
- Site and plant structures
- DCS (distributed control systems)
- HMI (human machine interface)
- Sensors for non-electric process variables
- Valves

PLT2: Process Control Engineering 2

Professor, Unit shortcut, and Unit name: **C - S**
Große, PLT2, Process Control Engineering 2
(German name: Prozessleittechnik 2)

Pre-requisites:
PLT1

Learning goals:

In general:
- Students will gather knowledge in open loop and closed loop control, recipe control and goals like plant performance, performance monitoring, safety and security

Module-specific:
- Students will learn about current standard techniques in PLC, SCADA (supervisory control and data acquisition), operator interfaces, real-time processing, computer networks, functional safety for human, environment and plant

Know-how/methods/learning/social competence:
- Students will learn to work in teams
- Multimedia presentation of results of teamwork
- Training to represent an enterprise
- Development of solution strategies

Professional preparation:
- Preparation of the complete corporate planning documents
- Teamwork
- Presentation skills
- Written skills

Contents:
- PLC (programmable logic controller)
- SCADA (supervisory control and data acquisition)
- Real-time operating systems
- Functional safety
- Data security
- Plant performance

PMM: Practical Mathematics using MATLAB

Lecturer, Unit shortcut, and Unit name: **C - W**
Korth, PMM, Practical mathematics using MATLAB
(German name: Praktische Mathematik mit Matlab)

Pre-requisites:
Elementary mathematics

Learning goals:
- Students are able to calculate simple to complex mathematical expressions, equations, matrix equations, functions,
- they are able to show solutions in a graphical environment and program mathematical problems.

Contents:
MATLAB, Scilab, Octave overview

Overview of the MATLAB environment
- Command window, workspace window, command history
- Help browser

First exercise in MATLAB
- Starting and quitting the MATLAB program
- Running functions and entering variables
- Basic commands and syntax
- Controlling input and output

Concepts of variables, numbers, math constants, operators, expressions, precedence rules for operators

Elementary math: trigonometric, exponential functions, logarithm, complex numbers, rounding and remainder

Basic mathematical concepts of vectors and matrices and their realisation in MATLAB

Graphics, Building 2-D graph
- Figure window, creating plots, basic plot control, graph annotation, subplots

MATLAB programming language
- Concept of scripts and functions (m files)
- Function handle, function functions
- Characters and strings
- Input and output operations
- Flow control: if, else, switch and case, for, while, break
- Relational and logical operators

PNV: Programming Numerical Algorithms

Professor, Unit shortcut, and Unit name: Stoffel, PNV, Programming Numerical Algorithms (German name: Programmierung numerischer Verfahren)	**C - S**

Pre-requisites:
EBR: Introduction to Operating Systems and Computer Networks
IN1: Practical Informatics 1
MA1: Mathematics 1

Learning goals:
- Students will know about the representation of floating-point arithmetic and the influence of round-off errors.
- Students will know some simple numerical algorithms.
- They will be able to implement simple algorithms using Scilab/MATLAB and C.

Contents:
- Floating-point arithmetic
- Round-off error and numerical instability
- Syntax of Scilab/MATLAB and C
- Solution of linear equations
- Numerical integration
- Newton's method for the calculation of zeroes of a function
- Numerical methods for ordinary differential equations

PR1: Process Control Computer Systems 1

Professor, Unit shortcut, and Unit name: Uerlings, PR1, Process Control Computer Systems 1 (German Name: Prozessrechentechnik 1)	**?? - W**
Pre-requisites: none	
Learning goals: In general: ➢ methods for planning automation projects ➢ design, realization and functional principles of automation systems, in particular setup, implementation style and programming of real-time computers as well as their configuration and interaction with the technical process Module specific: ➢ knowledge of the basic procedures in real-time computers ➢ analysis of coupling the technical process with the computer in different ways	
Contents: ➢ components of process automation systems ➢ structure of a real-time computer ➢ adapting of signals coming from / going to the technical process ➢ internal bus	

PR2: Process Control Computer Systems 2

Professor, Unit shortcut, and Unit name: Uerlings, PR2, Process Control Computer Systems 2 (German Name: Prozessrechentechnik 2)	**?? - S**
Pre-requisites: PR1	
Learning goals: In general: ➢ methods for planning automation projects ➢ design, realization and functional principles of automation systems, in particular setup, implementation style and programming of real-time computers as well as their configuration and interaction with the technical process Module specific: ➢ functional principles of peripheral components ➢ Shannon theorem of data acquisition ➢ Optimization of HW/SW interfaces	
Contents: ➢ processing of interrupts by hardware and software ➢ time intervals and deadlines concerning real-time computing ➢ analogue digital converters ➢ digital analogue converters ➢ operating real time clocks ➢ configuration of peripheral bus systems	

QKC: Source and Channel Coding

Professor, Unit shortcut, and Unit name: **C - W**
Dettmar, QKC, Source and Channel Coding
(German name: Quellen- und Kanalcodierung)

Pre-requisites:
- Mathematics: Finite Fields
- Digital Modulation (DMV)
- Signals and Systems 1 and 2 (analog and digital signals and the related transform techniques)

Learning goals:
General:
- to gain knowledge about principles in digital communications
- to gain experience with the application and testing of the corresponding procedures and algorithms

Module-specific:
- to learn about basics in information theory
- to understand the principles of source and channel coding
- to learn about practical codes
- to learn about techniques to increase the transmission rate and performance

Contents:
- Quantization
- Source Coding
- Channel Coding
- Link Budget Calculation
- Spread Spectrum
- Diversity Techniques

QM: Quality Management

Professor, Unit shortcut, and Unit name: **C - S**
Stoll, QM, Quality Management
(German name: Qualitätsmanagement)

Pre-requisites:

Learning goals:

In general:
- students will gather fundamental knowledge on quality management and quality assurance

Module-specific:
- students will learn about quality assurance as a management task
- they will gather knowledge on the most important methods and standards

Know-how/methods learning/social competence:
- students will evaluate advantages and problems that are related to the implementation, development and maintenance of a quality management system

Professional preparation:
- students will work on case studies
- they will evaluate job offers

Contents:
- Processes and structures in enterprises
- Total Quality Management (TQM, Quality Function Deployment, Kaizen, Zero Defect)
- Error diagnostics and reliability analysis (Failure Mode and Effect Analysis, Failure Tree Analysis)
- Problem solving (Plan Do Check Act, Kepner-Tregoe)
- ISO 9000

QME: Quantum Mechanics

Professor, Unit shortcut, and Unit name: **Cg - W**
Welker, QME, Quantum Mechanics
(German name: Quantenmechanik)

Pre-requisites:
PH1, MA1, MA2?, GE1, GE2?
fundamentals in physics; advanced knowledge in mathematics and electrical engineering

Learning goals:

In general:
- students will realize the necessity of quantization of physical quantities and the wave-particle dualism
- they will learn solution methods for complex differential equations using separation statements, expansion in power series, consideration of boundary conditions and asymptotic behavior. Introduction of Eigenfunctions&Eigenvalues and operators

Module-specific:
-

Know-how/methods learning/social competence:
- students will gain profound theoretical physical knowledge
- they will train their physical awareness for technical questions

Professional preparation:
- students learn to realize complex physical contexts
- they will be able to identify, evaluate, and compare essential parameters
- they train to become acquainted with theoretical questions

Contents:
- inadequacy of classical Physics: black body radiator, specific heats of solids, photoelectric effect, Compton-effect, Stern-Gerlach experiment, Bohr’s model, material waves
- experiments with spheres, waves ad electrons, basic principles of quantum mechanics,
- uncertainty principle
- wave function, particles and probability amplitude: combination law of amplitudes, identical particles
- Schrödinger equation: development of the wave equation, simple square potentials, harmonic oscillator, system of many particles
- application of Quantum mechanics: the H-atom, the solid
- perturbation theory

QT: Quality Engineering

Professor, Unit shortcut, and Unit name:	E - S
Stoll, QT, Quality Engineering (German name: Qualitätstechnik)	

Pre-requisites:
MA1, MA2?
Fundamentals in statistical distributions

Learning goals:

In general:
- students will gather fundamental knowledge on quality assurance

Module-specific:
- students will learn about choice and application of statistical methods in quality assurance

Know-how/methods learning/social competence:
- students will learn about preparation, calculation and implementation of statistical methods

Professional preparation:
- students will work on case studies

Contents:
- random sampling
- statistical process control (SPC)
- control charts
- process capability
- six sigma
- Design of Experiments (DoE)

RA: Digital Systems and Computer Architecture

Professor, Unit shortcut, and Unit name: **E - S**

Hartung, RA, Digital Systems and Computer Architecture
(German name: Digitale Systeme und Rechnerarchitektur)

Pre-requisites: **LANG=EN**

Course in basics of digital systems; preferably a course with an introduction to HDL and PLDs

Learning goals:

In general:

- Students learn to describe and construct digital systems, as well in theory as in practice. They learn how computers are constructed. They see the differences between architectural models, like RISC, CISC.

Module-specific: Students will

- understand the different views on a digital system following the Gajski/Kuhn model
- experience different forms to describe hardware systems (schematic, HDL)
- understand the different semantics of a hardware description (simulation vs. synthesis)
- know different models of digital processing, in special state machines, data flow, combined state/data flow, state machines with stack, processors
- understand a processor as a special digital module
- know different processor architectures
- know the mapping of a programming language onto a computer (processor and memory)

Know-how/methods/learning/social competence: Students will

- learn a HDL in depth (VHDL)
- use a HDL to describe state machines, combined state/data flow machines, processors
- understand technology issues in FPGAs
- understand the SOPC architecture with a multiplexed bus
- extend a given SOPC architecture with own modules
- write simple programs for “own” hardware
- interpret the execution of programming languages on computers (the runtime system)
- understand the “memory bottleneck” and its solution with caches and memory hierarchy

Contents:

1. Description of digital systems
   - VHDL-introduction; using VHDL to describe behavior, structure; using VHDL for data flow, state machines, extended state machines (with data flow) and processor description; VHDL as a simulation language for test and prototyping
2. Digital Technology
   - CMOS-transistor, logic gates, registers and latches, PLDs, FPGA, minimizing cell consumption
3. Computational models and computation in digital systems
   - state machines (with data path), stack machine, processor;
   - arithmetic units, filters; the SOPC idea
4. Introduction to computer architecture
   - principles of computer architecture (von Neumann etc.), construction of a processor, pipelining and other models for increasing throughput; memory issues, memory mapping, caches; multicore architectures
5. The software/hardware interface
   - Execution of interrupts and exceptions; memory and register allocation during execution of programs written in a programming language (C), interpretation of stack during the execution of programs

RAEO: Joint lecture on automation, energy, and optical technologies

Professor, Unit shortcut, and Unit name: **C - W**

Stadler / Lohner / Altmeyer, RAEO, Joint lecture on automation, energy, and optical technologies
(German name: Ringvorlesung Automatisierungstechnik, Energietechnik, Optische Technologien)

Pre-requisites:

Learning goals:

Introduction into different scopes of electrical energy technology, automation, and light, and discussion of challenges and occupation possibilities for electrical engineers.

Contents:

Energy situation
- Energy supply in Germany
- Energy supply worldwide
- Challenges with respect to resources and environment

The term “Energy”
- Energy and Power
- Units of energy and power
- Electrical, mechanical and thermal energy

Chain from primary energy to energy use
- Electricity generation
- Transmission and distribution of electrical energy
- Grid control technology, safety technology, high voltage technology
- Use of electrical energy

Particle and Wave
- straight propagation, shadows
- size of photons
- refraction as a consequence of varying speed, principle of a lens
- Michelson interferometer: light + light = darkness

Oscillators and waves
- examples for oscillators and mathematical description
- examples for waves and mathematical description
- light as a wave, introduction of all relevant parameters

Field and Intensity
- electrical field and intensity
- intensity and eye-damage of the sun compared with a laser pointer

Polarization
- vector character of the field, Jones vectors
- functionality of polarizators, technical applications

Wavelength
- wavelength and color
- the meaning of white in physics and in the human perception

Phase
- diffraction
- holography

RFSD: High Frequency System Design

Professor, Unit shortcut, and Unit name: Eg - **S**

Kronberger, RFSD, High Frequency System Design
(German name: Hochfrequenzsysteme und -komponenten)

Pre-requisites:
Basic studies, HF1, HF2 or HFS1 or HFS2

Learning goals:

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

Module-specific:
- students will get an introduction in rf systems
- they will learn about real wave propagation
- they will learn in detail how transmitters and receivers in wireless communication systems work
- they will learn in detail how the components of such systems (LNA, mixer, amplifier, oscillator, etc.) work
- they will learn about limitation effects and noise in such systems
- they will learn how to adapt the components to each other and how to plan and design the complete system (transmitter and / or receiver)
- they will learn about antennas for such systems

Know-how/methods/learning/social competence:
- theoretical fundamentals combined with practical examples will be explained
- students have to exercise themselves in practical circuit design
- a professional circuit simulation tool is used in parallel to support the lectures and exercises
- teaching material will be partially in English language

Professional preparation:
- they will know in detail about high frequency systems and components
- examples of current systems and components will be included and discussed (i.e. GSM, WLAN, etc.)
- they have learned to use a professional circuit simulation and design tool
- they have learned how to design a circuit

Contents:
- rf systems
- noise in rf systems (electronic noise, atmospheric noise, man made noise)
- real wave propagation in communication systems and propagation tools
- rf components (LNA, mixer, oscillator, PLL, power amplifier)
- communication antennas

RHP: Computer Design and Machine-intimate Programming

Professor, Unit shortcut, and Unit name: **C - S**
Thieling / Hartung, RHP, Computer Design and Machine-intimate Programming
(German name: Rechneraufbau und hardwarenahe Programmierung)

Pre-requisites:
Technical Informatics (DT)

Learning goals:

In general:
- Computer design and machine-intimate programming

Module specific:
- Micro computer, computer architecture and implementation, micro processors, programming concepts, machine-intimate programming in C

Know-how/methods/learning/social competence:
- Students will learn fundamental concepts and design principles of micro computers.
- Students will learn principle functions and methods to design and synthesize digital circuits. In small teams practical projects are implemented on a micro computer platform.

Professional preparation:
- Micro computer and embedded systems are today used in all areas of engineering to perform control tasks and to run complex applications implemented in software.

Contents:
- Computer architectures,
- information representation,
- programming concepts,
- machine-intimate programming in C
- I/O-programming (input/output) in micro computers

RM: Scanning Microscopy

Professor, Unit shortcut, and Unit name: **Eg - W**
Altmeyer, RM, Scanning Microscopy
(German name: Raster-Mikroskopie)

Pre-requisites:
MA1, MA2, PH1, PH2, GE1, GE2, OT1, OT2
Higher mathematics, basic knowledge in physics, deeper knowledge of: electrodynamics, beam optics and wave optics

Learning goals:

In general:
- Overcoming the limits of classical microscopy, concepts of modern imaging technologies and their theoretical foundations, practical experience with modern microscopes.

Know-how/methods/learning/social competence:
- The module is thought to deepen the knowledge in the theoretical backgrounds of imaging technologies. The additional mandatory practical trainings give a strong link to real life applications and problems. Additionally the hands on experiments provide an ease of handling of high end microscopy equipment.

Professional preparation:
- Students are to comprehend, that constructs of ideas like electrodynamics, special relativity or quantum mechanics, which are difficult to understand at a first glance, are ubiquitous in today's technical products. Therefore the related ultimate principles have to be understood as a conditio sine qua non. The additional hands on experiences with such high end equipment dispells existing reservations.

Contents:
- Scanning electron microscopy: wave-particle dualism ; de Broglie wavelength ; relativistic mass ; resolution of electron-optics ; depth of focus in an electron microscope ; physics of electron emission: thermoionic emission, Schottky emission and field emission ; technical configuration and specifics of thermoionic-, Schottky- and field-emitters ; brightness as the conservative of a beam ; electric and magnetic lenses and equations of motion for electrons in them ; distortions and their minimation in electron optics ; principles of electron beam lithography ; Interaction of fast electrons with matter: bach scattered electrons, secondary electrons, Auger electrons, bremsstrahlung, characteristic x-rays and cathodoluminecence ; principles of imaging on the basis of the named types of interactions ; topography-, material-, lattice-orientation- and conductivity contrast
- Scanning tunneling- and atomic force microscope: quantum mechanical description of the tunneling effect ; piezoelectric effect ; nonlinearity, hysteresis and creep of piezo drives ; closed loop feedback controls ; geometry and preparation of tunneling tips made of platinum and tungsten ; electronic density of states ; interpretation of the signal as a convolution of sample- and probe-geometry ; atomic resultion vs. lattice resolution ; contact mode and dynamic mode of an AFM ; amplitude- and phase-signal.
- Confocal laser scanning microscope: confocal principle ; point spread function ; transition from Gauss to Airy distribution ; pupil illumination and lateral resolution, confocal pinhole and depth discrimination

RP1: Research Project 1

Professor, Unit shortcut, and Unit name: Grebe, RP1, Research Project 1 (German name: Forschungsprojekt 1)	**Cg - S**

Pre-requisites:
Curricula specific knowledge and experiences in the Master course Communications Systems and Networks. Successfully completed Bachelor studies in informatics or electrical engineering (information technologies or communication technologies).

Learning goals:
- Within a medium sized project, coached by one of the professors teaching in the Master course Communications Systems and Networks, the students will demonstrate and deepen their capabilities to perform scientific works and transfer to practices.
- The students will work on an actual problem in applied sciences which may be proposed by a Professor, by the students themselves, or an external scientific, or industrial partner. The project should fit to the work in the research center for Next Generation Services in Heterogeneous Network Infrastructures (NEGSIT).
- The project may be done by a single student or a small team of students. Beside the work on scientific problems and their solutions the students will train project planning and management skills. The project will be defended in a public presentation and ends in a written scientific documentation.

Contents:
Scientific work on an actual topic from communications systems and networks.

RP2: Research Project 2

Professor, Unit shortcut, and Unit name: Grebe, RP1, Research Project 2 (German name: Forschungsprojekt 2)	**Cg - W**

Pre-requisites:
Curricula specific knowledge and experiences in the Master course Communications Systems and Networks. Successfully completed Bachelor studies in informatics or electrical engineering (information technologies or communication technologies).

Learning goals:
- Within a medium sized project, coached by one of the professors teaching in the Master course Communications Systems and Networks, the students will demonstrate and deepen their capabilities to perform scientific works and transfer to practices.
- The students will work on an actual problem in applied sciences which may be proposed by a Professor, by the students themselves, or an external scientific, or industrial partner. The project should fit to the work in the research center for Next Generation Services in Heterogeneous Network Infrastructures (NEGSIT).
- The project may be done by a single student or a small team of students. Beside the work on scientific problems and their solutions the students will train project planning and management skills. The project will be defended in a public presentation and ends in a written scientific documentation.

Contents:
Scientific work on an actual topic from communications systems and networks.

RST: Recipe Control

Professor, Unit shortcut, and Unit name: **E - W**
Große / Schorn, RST, Recipe Control
(German name: Rezeptsteuerung)

Pre-requisites:
PLT1

Learning goals:
- Realization of basic automation with different representation methods and programming languages (DIN EN 61131-3)
- Representation of control proceedings with GRAFCET
- Projection of processes at plants and recipes
- Handling of procedure function charts

Contents:
- Basic automation according to DIN EN 61512-1:
  - Interlock control; logic control with FUP, KOP, CFC according to DIN EN 61131-3
  - Control functions / sequential control; flow charts with GRAFCET according to DIN EN 60848
  - Control functions / sequential control; flow charts with SFC according to DIN EN 61131-3
  - Control functions / sequential control; flow charts with ST according to DIN EN 61131-3
- Concepts of recipe control according to DIN EN 61512-1:
  - Types and structures of recipes; control components
  - Representation of master recipes and control recipes
  - Procedure function charts according to DIN EN 61512-2
- Demonstration of a given recipe control system:
  - Operating Centum (Yokogawa)

RT: Basic of Control System Technology

Professor, Unit shortcut, and Unit name: **E - S**
Große, RT, Basic of Control System Technology
(German name: Regelungstechnik)

Pre-requisites:
MA1, MA2, GE1, GE2, ASS
Integrals; derivatives; trigonometric-, exponential-, and logarithmic functions; limits; partial fractions expansion; complex numbers; Fourier series and transform; R-, L-, and C-circuits; solving of differential equations

Learning goals:
- Basic and extended knowledge about control systems in theory and application
- Linearization and representation of plants (systems) in time and frequency domain
- Basic controller schemes, their effect on the system, advantages/disadvantages: tradeoffs
- Representation of systems by equivalent block diagrams
- Fundamentals of the Laplace transform of systems
- Identification of the characteristics of a system in time and frequency domain, their representation in appropriate diagrams, and the appropriate interpretation
- Determine stability of a closed loop system
- Correct selection of a controller type and its parameterization in time and frequency domain for a single loop feedback system
- Ability to build models from real world systems (preferably temperature or motion control) and to abstract from reality
- Working with the abstract system and understanding the relationship with the real system

Contents:
- Introduction to control system technology
- Steady state behavior of a system / plant
- Linearization and characterization of a system
- Dynamic behavior
- Basic controller schemes, P, I, PI, PD, and PID
- Closed loop stability
- Damping criteria for control system Design
- Nyquist, phase margin, and gain margin
- Cascaded feedback control

RT1: Basic of Control System Technology 1

Professor, Unit shortcut, and Unit name: **C - S**
Große / Krah, RT1, Basic of Control System Technology 1
(German name: Regelungstechnik 1)

Pre-requisites:
MA1, MA2, GE1, GE2, ASS
Integrals; derivatives; trigonometric-, exponential-, and logarithmic functions; limits; partial fractions expansion; complex numbers; Fourier series and transform; R-, L-, and C-circuits; solving of differential equations

Learning goals:
- Basic and extended knowledge about control systems in theory and application
- Linearization and representation of plants (systems) in time and frequency domain
- Basic controller schemes, their effect on the system, advantages/disadvantages: tradeoffs
- Representation of systems by equivalent block diagrams
- Fundamentals of the Laplace transform of systems
- Identification of the characteristics of a system in time and frequency domain, their representation in appropriate diagrams, and the appropriate interpretation
- Determine stability of a closed loop system
- Correct selection of a controller type and its parameterization in time and frequency domain for a single loop feedback system
- Ability to build models from real world systems (preferably temperature or motion control) and to abstract from reality
- Working with the abstract system and understanding the relationship with the real system

Contents:
- Introduction to control system technology
- Steady state behavior of a system / plant
- Linearization and characterization of a system
- Dynamic behavior
- Basic controller schemes, P, I, PI, PD, and PID
- Closed loop stability
- Damping criteria for control system Design
- Nyquist, phase margin, and gain margin
- Cascaded feedback control

RTE: Routing and Traffic Engineering

Professor, Unit shortcut, and Unit name: Böhmer (FH BRS), RTE, Routing and Traffic Engineering (German name: Routing und Traffic Engineering)	Eg - W

Pre-requisites:

Learning goals:

-

Contents:

- Algorithms for routing protocols
- Adaptive/non-adaptive and hierarchical routing methods
- Redundancy, symmetry, and load sharing
- Design and optimization of network infrastructures
- Simulative performance rating of network infrastructures
- Applications and protocols, e.g. OSPF, BGP, mobile IP, and SIP

SA: Software Engineering for Automation

Professor, Unit shortcut, and Unit name: **C - W**

Kreiser, SA, Software Engineering for Automation
(German name: Software Engineering)

Pre-requisites:

Practical Informatics (PI1, PI2), Foundations of Technical Computer Science (GTI)
Good theoretical knowledge and at least some practical experience in one modern programming language, object oriented programming basics

Learning goals:

In general:

- Provide a broad overview on quality-controlled development of complex technical software systems
- Get fundamental knowledge on software project organisation in a regulated business environment

Module-specific:

- Software system modelling using UML (Unified Modelling Language), use a commercial modelling tool
- Perform Round-Trip-Engineering (using modelling tool and Microsoft Visual Studio): reverse engineering of code, remodelling, model extension and model refactoring, code generation, coding (C++), testing
- Practice a quality controlled software development on several real world software development tasks, e.g. one software system for a check-out system in a supermarket.
- Learn how a systematic predictable software development process should be structured and founded on standardized development procedures, what the minimum requirements on such a development process are and how these requirements can be successfully met through the decisive collaboration of a team of developers.

Know-how/methods/learning/social competence:

- Understand and use universal abstract methods to model and manufacture complex software systems.
- Learn to evaluate modern and future software modelling techniques and notations with respect to their usability for special modelling purposes and their restrictions in use.
- Learn about general structures in business organisations, standardized business project metrics, technical and business goals, regulatory guidelines etc. and how they influence software development processes and software system life cycles
- Learn to extract relevant information out of comprehensive texts (German and English language)

Professional preparation:

- Build abstract models of complex software systems meeting given real world requirements
- Quality controlled processing of software development projects by interdisciplinary international teams.

Contents:

- Introduction to software engineering (software complexity, potential fields of errors in software systems, quality indicators)
- Modelling complex software systems using UML: system view, interfaces, structural, behavioural models
- Architectural design of complex software systems using UML: packages, components, nodes, best practise design principles, standard architectures, workflow control management, message passing principles, real time aspects
- Project management for the development of high quality technical software systems, project organisation
- Standardized software development procedures
- Requirements engineering, documentation of design input requirements
- Software system development including overview on risk assessment/management, feasibility studies, Pflichtenheft (design specification)
- Implementing software systems as a team goal, coding standards, integrated development tools, code and version management tools
- Verification & Validation (V&V), audits, common review techniques (peer review, code review)

SE: Software Engineering

Professor, Unit shortcut, and Unit name: **C - W**
Nissen, SE, Software Engineering
(German name: Software Engineering)

Pre-requisites:
Practical Informatics 1+2
Foundations of Computer Science, General Programming Skills, Object-Oriented Programming

Learning goals:
In general:
- problem understanding and solving
- quality awareness
- Structuring of a complex software-based problem description into manageable parts (components). Preparation of solutions for the components in compliance with it's interface specifications. Integration of components to build the complete system.

Module-specific:
- Systematic development of complex software systems with high and predictable quality
- Control and tailoring of process models

Know-how/methods/learning/social competence:
- Knowledge in quality-driven methods for the development and verification of complex software systems
- Communication skills
- Cooperation in teams

Professional preparation:
- Handling of incomplete and inconsistent information
- Software development for a larger, realistic problem in the lab

Contents:
- Motivation for quality-driven software development
- Process models for development of complex software systems
- Object-oriented modeling with UML
- Requirements engineering
- System analysis and system specification
- System design
- Software design
- Implementation
- Verification and validation

SEKM: Design of Complex SW Systems using Components and Pattern

Professor, Unit shortcut, and Unit name: Eg - **S**

Kreiser, SEKM, Design of Complex Software Systems using Components and Pattern
(German name: Entwurf komplexer Softwaresysteme mit Komponenten und Mustern)

Pre-requisites:

Practical Informatics (PI1, PI2), essential parts of Software Engineering (SE), i.e.
it is assumed, that the students have a good theoretical knowledge and at least basic practical experience in one modern programming language (C/C++ preferred), object oriented programming basics, basic UML notations (Unified Modelling Language) for structural and behavioural models, pattern basics, software development processes

Learning goals:

In general:

- Build high quality distributed software systems based on modular best practise structures and a reusable component architecture using appropriate software engineering processes

Module specific:

- Discuss the ideas of: components and frameworks, abstraction layers in a software architecture, middleware, reuse and programming vs. component configuration with respect to a quality controlled software development process driven by distributed development teams.
- Practice a quality controlled, component based software development by example of several software components which typically are essential parts of a process control system for technical processes.

Know-how/methods/learning/social competence:

- Gain a broad insight into the typical structures of distributed component based software systems.
- Learn how an appropriate software development process can be designed, what the minimum requirements on such a development process are and how these requirements can be successfully met
- Explore the benefits of software development pattern and learn how to use such pattern for the design of robust distributed real-time software systems.
- Learn to extract relevant information out of comprehensive scientific texts (German / English language)

Professional preparation:

- Design software systems based on component architectures
- Learn how to efficiently collaborate in a(n international) team of developers.
- Present complex technical information, e.g. a selected pattern for distributed systems, essentials of a distribution model related to automation software systems, essentials of agent based software systems related to automation software systems etc. to a known auditorium within a given timeframe (seminar work).

Contents:

- Managing complexity in distributed automation software systems by reuse of software artefacts, white-box-reuse, grey-box-reuse, black-box-reuse
- Essential architectural pattern and essential pattern for distributed real time systems, pattern languages, software engineering with pattern
- Component based software systems (components and their configuration, framework architecture, hardware requirements, requirements on system software, streamlined quality management through reuse of approved software artefacts, team development)
- Component and framework design (advanced message passing models, code portability through middleware abstraction)
- Discussion of and assessment on standard (commercial) distribution models, e.g. CORBA, .NET
- Fundamentals of agent based software systems (optional)

SI2: IT-Security 2

Professor, Unit shortcut, and Unit name: Knospe, SI2, IT-Security 2 (German name: IT-Sicherheit 2)	**C - S**
Pre-requisites: KRY Programming languages (Java and C), operating systems (in particular Unix/Linux), computer networks, software engineering. English language skills are required (English lecture notes).	
Learning goals: ➢ The students can analyze the security of IT systems and networks and know methods to construct secure systems. ➢ They understand public key infrastructures and know models and methods for authentication and access control. ➢ They analyze threats for communication systems and implement network security mechanisms. ➢ They know the security process and how to establish an Information Security Management System.	
Contents: ➢ Introduction to Information Security: security objectives, vulnerabilities, threats, attacks, risk evaluation, security policy, security concept ➢ Trust management, Public-Key Infrastructures (PKI), certificates, signatures law, trusted computing ➢ Identification and authentication, passwords, one-time passwords, challenge-response methods, smart cards, Kerberos ➢ Access control models, access matrix, capabilities, Role Based Access Control (RBAC), Bell-LaPadula model, system security in Unix/Linux and Windows operating systems ➢ Network Security: security objectives and threats, integration of security services, security protocols for all layers: EAP, IEEE 802.1X, PPTP/L2TP, IPsec (ISAKMP/IKE/IKEv2, ESP, AH), SSL/TLS, SSH, S/MIME, PGP, Firewall architectures ➢ Software safety and security, exploits, malicious code ➢ Legal aspects of information security ➢ Security management, security standards, ISO 27001, Information Security Management System (ISMS), IT security process, certification, Common Criteria (CC)	

SIM: Simulation in Engineering Sciences

Professor, Unit shortcut, and Unit name: Brämer, SIM, Simulation in Engineering Sciences (German name: Simulation in der Ingenieurwissenschaft)	Eg - ??
Pre-requisites:	
Learning goals: Substitution of real systems by modelling and computing the differential equations, dynamic behavior of energy transformer	
Contents: Modelling, analysis, and optimization of dynamic systems out of the energy- and motor drive technology	

SNLB: Systems and Networks Lab

Professor, Unit shortcut, and Unit name: **Cg - W**
Leischner / Knospe / Grebe / Elders-Boll / Dettmar, SNLB, Systems and Networks Lab
(German name: Praktikum Systeme und Netze)

Pre-requisites:
Project dependent requirements; however, attendance of the lectures in the first term is mandatory

Learning goals:

In general:
- to transform their theoretical knowledge into the solution of small practical problems from the area of digital systems and networks
- to learn about team work
- to deepen the understanding from the lectures

Module-specific:
- to learn about the analysis of a given problem
- to learn the choice and application of appropriate SW tools
- to understand actual principles of digital systems and networks
- to learn about the solution of practical problems

Know-how/methods/learning/social competence:
- they will be able to apply temporary SW tools
- they will train their algorithmic thinking

Professional preparation:
- students learn basics of project management
- they learn basics on algorithms and their implementation

Contents:
- depends on the actual projects
- strongly related to the contents of the first term lectures

SNT: Switched Mode Power Supplies

Professor, Unit shortcut, and Unit name: E - **W**
(NF van der Broeck), SNT, Switched Mode Power Supplies
(German name: Schaltnetzteile)

Pre-requisites:
Electrical Engineering 1+2

Learning goals:

In general:
- The students learn the basic principles of switched mode power supplies SMPS

Module-specific:
- The lecture deals with single ended and half-bridge converter based on power MOSFETs for power levels up to 1kW
- The students understand the importance of switched mode power supplies for increasing efficiency and power density in electronic systems

Professional preparation:
- Within the lecture state of the art switched mode power supplies from domestic, consumer, telecom and automotive applications are presented

Contents:
- Disadvantages of conventional linear power supplies
- Passive and active components for SMPS
- Steady state and dynamic behavior of switched networks
- Buck converter
- Continuous and discontinuous operation mode
- Forward converter
- Boost converter
- Input rectifier with power factor correction PFC
- Buck-boost converter
- Flyback converter
- Voltage and current mode control schemes
- Half-bridge topology
- Series resonant converter
- Zero current and zero voltage switching
- Electronic ballast for lighting
- Differential and common mode interference & HF filter circuits

SREA: Control and Feedback Control Systems of Electrical Drives

Professor, Unit shortcut, and Unit name: E - **W**

Lohner, SREA, Control and Feedback Control Systems of Electrical Drives
(German name: Steuerungs- und Regelungstechnik Elektrischer Antriebe)

Pre-requisites:

- Principles of Electrical Engineering 1 & 2,
- Power Electronics,
- Principles of Electrical Drives,
- Analog Signals and Systems

Learning goals:

In general:

- students will hear something about the structure and the control of modern electrical drives.

Module-specific:

- students become acquainted with different drives and control strategies.

Know-how/methods/learning/social competence:

- students will be able to understand the components of an electrical drive,
- they will be familiar with the control algorithms of the most important machines,
- they will know the field oriented control of the induction machine,
- they will be able to represent electrical machines by their models,
- they are familiar with simulation of drives,
- they will learn to design drive control in theory and application.

Professional preparation:

- The module content is presented according to actual developments in the field of intelligent motion.

Contents:

- equivalent circuit diagrams of different electrical machines,
- dynamic behavior of electrical machines,
- different power converter topologies for electrical machines,
- PWM, drive control algorithms,
- principle of the field oriented control of the induction machine,
- on the induction machine based modern propulsion system (converter, control, CAN-bus).

SS: Switching Plants and Switching Devices

Professor, Unit shortcut, and Unit name: **C - W**
Nachtigall, SS, Switching Plants and Switching Devices
(German name: Schaltanlagen und Schaltgeräte)

Pre-requisites:
HS1, WK, PH2
Recovery voltage, A-Fritting, B-Fritting, ionisation, quasi equilibrium, discharge, plasma, electrodes, circuit breakers, material data, influence of temperature or aggressive gases, surface conditions of materials, current density, contracting and repelling forces between conductors, ionisation energy, work function

Learning goals:
- students will gather knowledge on fundamentals of switching plants and switching devices
- they will know about the plasma physics when switching or conducting current
- they will know about the temperature load of switching devices when operating with nominal, heavy duty or in case of short circuit
- they will understand selectivity
- they will be able to design power plants taking into account the selectivity
- they will understand circuit diagrams
- they know about the different switching devices for different purposes
- they will learn about the standards

Contents:
- different switching principles and research
- conducting and switching of current
- electrical and mechanical lifetime
- AC/DC duty according to the standards
- contact physics
- plasma, arcing
- arc quenching dc and ac
- standards
- selectivity
- design of circuit breakers and contactors

STE: Control System Technology

Professor, Unit shortcut, and Unit name:	C - S
Kreiser, STE, Control System Technology (German name: Steuerungstechnik)	

Pre-requisites:
- Practical Informatics (PI1, PI2),
- Foundations of Technical Computer Science (GTI),
- Analogue Signals and Systems (ASS).

Especially: general OO-programming skills, digital system modelling, finite automata / state chart representations, discretisation of amplitude-analogue signals

Learning goals:

In general:
- Model and design discrete event driven systems using Petri-Nets (S/T-Nets) and/or other graphs with similar modelling capabilities, e.g. parallelized Harel State Charts
- Implement controller models on typical automation computer systems, i.e. PLC based, µC based
- Manage complex automation tasks by decomposition into sound and manageable subtasks which are independently resolvable by different individuals.

Module-specific:
- Managing event driven real time systems
- Compose complex automation systems out of suitable (commercial) parts (commercial instruments, bus systems etc.) based on general system and user requirements.
- Implement complex control systems by means of standardized programming languages, i.e. EN 61131-3 languages and / or similar proprietary languages.
- Generate control system implementations based on graphical models, e.g. based on Petri-Nets or Harel State Charts.

Know-how/methods/learning/social competence:
- Learn to extract relevant information out of comprehensive texts (German and English language)
- Define suitable control subsystem borders and dedicated interfaces. Design controller implementations compliant to the given interface definitions. Perform subsystem tests, integrate released subsystems and perform global system tests.
- Perform an automation project work with a predefined deadline in a(n international) project team.

Professional preparation:
- Project work: Automate a given model plant based on given design input requirements. Implement the discrete control system on a commercial PLC-system based on graphical control system representations and EN 61131-3 standardized programming languages.
- Understand and use comprehensive requirements documents for efficient system development
- Build abstract models of complex discrete control systems meeting given real world requirements.

Contents:
- Compose discrete distributed automation systems using typical commercial subsystems.
- Overview on usage and internal structure of automation instruments, safety aspects
- OSI-Communication in distributed automation systems including an overview on modern fieldbus technology and industrial Ethernet
- Programming real time control systems on µC and PLC.
- PLC system design. Overview on EN ISO 61131. Standardized PLC programming languages (EN ISO 61131-3) and popular similar proprietary languages.
- PLC controller design using a commercial IDE.
- Petri-Net based modelling, design, simulation and evaluation of distributed automation systems / concurrent processes. Hierarchical Petri-Nets. Control system representations by Petri-Nets.

STO: Probability and Statistics

Professor, Unit shortcut, and Unit name: Stoffel, STO, Probability and Statistics (German name: Stochastik)	C - S

Pre-requisites:
Mathematics 1: sets and mappings, calculus
Practical Mathematics with MATLAB: knowledge in MATLAB

Learning goals:
The students should acquire fundamental knowledge in probability and statistics. They should understand important notions and technics of probability and statistics and should be able to apply them. In particular, they should be able to analyze data using statistical methods. They should know the importance of expectation values and distributions for random variables. Furthermore, they should know some important special distributions and linear regression.

Contents:
- Description of data sets
- Summarizing statistics: sample mean, sample median, quantiles, empirical variance
- Combinatorics
- Permutations
- Random experiments and probability
- Discrete random experiments, definition of the probability of an event.
- Conditional probability and independence
- Random variables and distribution functions
- Discrete distributions, binomial distribution, continuous distributions
- Probability density function, histogram, normal distribution
- Expectation value and variance
- Two- and multidimensional distributions
- Covariance, Correlation
- Introduction to inferential statistics
- Parameter estimation, confidence interval, hypothesis testing
- Linear regression

SUS1: Signals and Systems 1

Professor, Unit shortcut, and Unit name: **C - W**

Elders-Boll, SUS1, Signals and Systems 1
(German name: Signale und Systeme 1)

Pre-requisites:

MA1, MA2, GE1, GE2
Integrals; derivatives; trigonometric, exponential, and logarithmic functions; limits; series; partial fraction expansion; complex numbers; complex representation of alternating current, impedance, phasor representation

Learning goals:

- This module conveys the fundamental concepts of theory and application of signals and systems.
- Students are able to characterize and classify signals and systems, to describe analogue and discrete-time signals and systems in the time and frequency domain and to determine the stability of systems.
- The students know how to describe sampling of analogue signals and are able to determine under which circumstances the analogue signal can be reconstructed perfectly from the sampled signal.

Contents:

Fundamental Concepts

- Classification of signals: analogue, discrete-time, discrete-valued and digital signals, deterministic and stochastic signals, periodic and aperiodic signals, systems, examples for analogue and discrete-time systems

Deterministic Signals and Linear Time-invariant Systems

- Basic signals, linear time-invariant systems,
- superposition principle, discrete-time convolution, impulse and impulse response, convolution integral, properties of the convolution product,
- important systems: integrator, running sum, differentiator and difference,
- further properties of systems: causality, stability, difference equations and block diagrams, FIR and IIR systems

Fourier Transform of analogue Signals

- Eigensignals of LTI systems, transfer function,
- Fourier series, Fourier integral, theorems and examples,
- energy density spectrum

Sampling

- Fourier transform of an Dirac impulse train,
- sampling in the time domain

Fourier Transform of discrete-time Signals (DTFT)

- Energy of discrete-time signals,
- DTFT, theorems and examples, oversampling

SUS2: Signals and Systems 2

Professor, Unit shortcut, and Unit name: Elders-Boll, SUS2, Signals and Systems 2 (German name: Signale und Systeme 2)	C - S

Pre-requisites:
SUS1,
Complete contents of Signals and Systems 1 in particular analogue LTI and discrete-time LSI systems, convolution, Fourier transform, sampling, DTFT

Learning goals:
- This module conveys the advanced concepts of theory and application of signals and systems.
- Students are able to describe signals and systems via the Laplace- and z-transform, characterize LTI systems by pole/zero plots and determine the stability of LTI systems from pole-zero plots.
- Students know the fundamental challenges of analogue filter design and are able to analyze signals in the frequency domain using the FTT and know the effects that might occur.

Contents:
Laplace Transform
- The single-sided Laplace transform, properties of the Laplace transformation,
- s-transfer function, differential equations,
- pole/zero plots, stability,
- Bode plots

The z-transform
- Two-sided and single-sided z-transform, Properties of the z-transform, the inverse z-transform,
- z-transfer function,
- pole/zero plots, stability

The discrete Fourier Transformation (DFT)
- Sampling in the frequency domain, DFT, resolution in the time and frequency domain,
- circular convolution,
- Fast Fourier-Transformation (FFT),
- leakage effect, window functions

Decimation and Interpolation
- Decimation, interpolation, interpolation for D/A conversion

Introduction to Filter Design
- Requirements, frequency domain specification,
- analogue filter design, examples,
- digital filter design, impulse-invariant transform, bilinear transform, comparison of FIR- and IIR filters

SW1: Software Lab 1

Professor, Unit shortcut, and Unit name: **C - S**
Nissen, SW1, Software Lab 1
(German name: Software-Praktikum 1)

Pre-requisites:
PI1, PI2, SE
Programming; Software Engineering methods and process models; verification techniques; quality management methods

Learning goals:

In general:
- Working on own responsibility
- Working in a project, with fixed time limit, defined problem area and limited resources

Module specific:
- Systematic development of a complex software system
- Planning and management of a software development project
- Working in a project which lasts for several months

Know-how/methods/learning/social competence:
- Working in team for several months
- Application of software engineering methods and techniques

Professional preparation:
- Working on own initiative
- Presentation of work results to the customer

Contents:
- Capture and documentation of customer requirements
- Analysis, specification and design of a software system
- Implementation in a team, based on interface specifications
- Verification of a software system and documentation of the results
- Preparation of user and developer documentation
- Three presentations of work results at pre-defined milestones to the customer and other people

SW2: Software Lab 2

Professor, Unit shortcut, and Unit name: Nissen, SW2, Software Lab 2 (German name: Software-Praktikum 2)	**C - W**
Pre-requisites: PI1, PI2, SE Programming; Software Engineering methods and process models; verification techniques; quality management methods	
Learning goals: In general: ➢ Working on own responsibility ➢ Working in a project, with fixed time limit, defined problem area and limited resources Module specific: ➢ Systematic development of a complex software system ➢ Planning and management of a software development project ➢ Working in a project which lasts for several months Know-how/methods/learning/social competence: ➢ Working in team for several months ➢ Application of software engineering methods and techniques Professional preparation: ➢ Working on own initiative ➢ Presentation of work results to the customer	
Contents: ➢ Capture and documentation of customer requirements ➢ Analysis, specification and design of a software system ➢ Implementation in a team, based on interface specifications ➢ Verification of a software system and documentation of the results ➢ Preparation of user and developer documentation ➢ Three presentations of work results at pre-defined milestones to the customer and other people	

TA1: Acoustics 1

Professor, Unit shortcut, and Unit name:	E - **W**
Pörschmann, TA1, Acoustics 1 (German name: Technische Akustik 1)	

Pre-requisites:
Fundamentals of mechanics, current, voltage, passive elements (resistors, inductors, capacitors), arithmetic with complex numbers, time domain and frequency domain, basics of differential and infinitesimal calculus

Learning goals:
- Fundamental knowledge of acoustics,
- overview on acoustics,
- introduction of the basic acoustic principles,
- description of the propagation of sound,
- principle set-up of loudspeakers and microphones including the electro acoustic conversion of energy.

Content:
Introduction of the basic acoustic principles:
- Sound pressure, sound particle velocity, sound power

Mechanic and acoustic resonance systems:
- Mechanical resonance systems, acoustical resonance systems, electro acoustic and electro mechanic analogies

Sound propagation:
- homogeneous plane waves, standing waves, resonances, point sources, funnels, reflection, absorption, synthesis of point sources

Microphones and loudspeakers:
- Principles of directional microphones
- Electro-dynamic microphones and headphones
- Piezo-electrical microphones and headphones, dielectric microphones

TA2: Acoustics 2

Professor, Unit shortcut, and Unit name: Pörschmann, TA2; Acoustics 2 (German name: Technische Akustik 2)	E - **S**
Pre-requisites: Fundamentals of mechanics, current, voltage, passive elements (resistors, inductors, capacitors), arithmetic with complex numbers, time domain and frequency domain, basics of differential and infinitesimal calculus, basics of digital signal processing, basic acoustic principles, principles of the propagation of sound, loudspeakers and microphones, electro acoustic conversion of energy	
Learning goals: ➢ Fundamental knowledge of acoustics, ➢ overview on acoustics, ➢ apply the techniques and know how from Acoustics I on different problems in the field of room acoustics, noise protection, human perception of sound and audio signal processing	
Content: Room acoustics, building acoustics: ➢ Principles of room acoustics, Introduction to a common software tool for room simulation, determination of building acoustics properties, system analysis of noise Hearing acoustics: ➢ Function of outer, middle and inner ear, implication of ear anatomy on human sound perception Psycho acoustics: ➢ Loudness and pitch perception, relationship between physical and psychoacoustic properties, implications for technical products and applications Human sound production: ➢ Human speech apparatus, speech synthesis, speech recognition, speech signal processing	

TE1: Technical English 1

Lecturer, Unit shortcut, and Unit name: **C - W**
Henzel / Lunny / MacKinnon / Scholemann, TE1, Technical English 1
(German Name: Technisches Englisch 1)

Pre-requisites:
Basic knowledge of English grammar and vocabulary (5 years of school English or equivalent)

Learning goals:

In general:
- students will be able to communicate effectively about topics related to current affairs and their studies
- they will be able to understand simple technical texts
- they will be able to interpret charts and graphs
- they will be able to describe simple mathematical operations

Contents:
- revision of grammar
- core technical vocabulary
- short presentations
- discussions

TE2: Technical English 2

Lecturer, Unit shortcut, and Unit name: **C - W**
Scholemann, TE1, Technical English 1
(German Name: Technisches Englisch 1)

Pre-requisites:
Basic knowledge of English grammar and vocabulary (5 years of school English or equivalent), willingness to participate actively

Learning goals:

In general:
- students are incited to (re)activate their existing language skills
- they will get to know strategies to acquire and absorb new vocabulary
- they will be able to use the Internet as a tool to improve their language skills autonomously
- they will be able to describe technical circumstances and express their personal analysis

Contents:
- technical vocabulary (e.g. mathematical operations, electronic circuits, signals and systems, physical units, economics, mechanics)
- grammar revision – (e.g. questions and negative sentences, Genitives, adjectives)
- short presentations/debating on technical issues/re-enacting dialogues
- listening comprehension, reading of authentic material

TEMB: Technology of Electrical Machines

Professor, Unit shortcut, and Unit name: Eg - ??

Brämer, TEMB, Technology of Electrical Machines
(German name: Technologie im Elektro-Maschinenbau)

Pre-requisites:
Fundamentals of electrical machines and transformers

Learning goals:
- Fundamental technological knowledge about changing techniques in electromechanical engineering

Contents:
- Permanent exciting field
- Technology of electrical machines with highest rating
- Cryogenic generator
- Roboter with 5 axis at 2 coordinate systems
- Different types of transformers

TEN: Technical English

Lecturer, Unit shortcut, and Unit name: **C - S**

Henzel / Lunny / MacKinnon / Scholemann, TEN, Technical English
(German Name: Technisches Englisch)

Pre-requisites:
Basic knowledge of English grammar and vocabulary (5 years of school English or equivalent)

Learning goals:

In general:
- students will be able to communicate effectively about topics related to current affairs and their studies
- they will be able to understand simple technical texts
- they will be able to interpret charts and graphs
- they will be able to describe simple mathematical operations

Contents:
- revision of grammar
- core technical vocabulary
- short presentations
- discussions

THI: Theoretical Computer Science

Professor, Unit shortcut, and Unit name: Randerath, THI, Theoretical Computer Science (German Name: Theoretische Informatik)	**Cg - W**
Pre-requisites: FSA, Adequate knowledge of Formal Languages and Automata theory.	
Learning goals: In general: ➢ students will gather knowledge experience in working with abstract formalisms Module specific: ➢ students will know about type1- and type0-languages, decidability results regarding these languages and its corresponding machine models ➢ they will know about different concepts of computability, computational complexity and about relevant complexity classes ➢ they will know about the fundamentals of decidability theory and will be able to apply these insights to real world problems. This also includes the knowledge on the existence of undecidable problems and some relevant examples ➢ they will be able to determine the computational complexity of algorithms ➢ they will know about the importance of the P versus NP problem and they will know NP-complete problems, especially of those ones motivated by real world applications. ➢ they will be able to reduce NP-complete problems to intractable problems motivated by real world applications (if possible). ➢ they will have a basic knowledge on heuristic and approximative solutions of intractable problems	
Contents: ➢ **Typ-1- und Typ-0-languages**: kontext-sensitive and recursive-enumerable languages, Chomsky-hierarchy, decidability of the word problem ➢ **Turing-machine**: Variations of the turing-machine and its equivalence, the equivalence of languages accepted by linear bounded automata and Typ-1 languages, the equivalence of languages accepted by Turing-machines and Typ-0 languages. ➢ **Computability**: Turing-, While- and Goto-Computability and its equivalence; Church-Turing thesis; Loop-Computability; Ackermann-function, universal Turing-machine and its impact towards programming languages ➢ **Decidability**: decidable and semi-decidable problems; reductions of problems; undecidable problems ➢ **Computational Complexity**: O-Landau-Notation; computational complexity of algorithms, complexitity classes; P versus NP-problem; NP-complete and NP-hard problems ➢ Introduction to heuristic and approximative solutions of intractable problems	

UET1: Introduction to Digital Communication Systems

Professor, Unit shortcut, and Unit name: E - **W**

Elders-Boll, UET1, Introduction to Digital Communication Systems
(German name: Übertragungstechnik 1)

Pre-requisites:
ASS (may be taken concurrently)
Fourier Transform, Convolution, Correlation Functions of Deterministic Signals, Sampling Theorem

Learning goals:

In general:
- Knowledge of the fundamentals of digital communication systems

Professional preparation:
- know the reason why analog systems are being replaced by digital communications systems
- know criteria to be able to select an appropriate communication system for a specific purpose
- students are familiar with MATLAB

Contents:
- General block diagram of digital communication systems
- Sample space, events, probability law. Conditional probability. Independence, random variables. Distribution, density functions
- Introduction to information theory: self-information, entropy, redundancy, channel capacity
- Stochastic signals: random processes, stationarity, correlation functions, power density spectrum,
- Binary passband communication systems: optimum receiver in noisy channels,

UT: Introduction to Digital Communications

Professor, Unit shortcut, and Unit name: **C - W**

Elders-Boll, UT, Introduction to Digital Communications
(German name: Einführung in die Übertragungstechnik)

Pre-requisites:

MA1, MA2: integrals; derivatives; trigonometric, exponential, and logarithmic functions
STO: probability, random variable, expected values, probability distribution function,
SUS1: (can be taken concurrently): LTI Systems, convolution, Fourier transform

Learning goals:

- This module conveys the fundamental concepts of modern digital communication systems in particular of binary communication systems, which are being used in every modern communication systems.
- The students are able to describe random variables by distribution functions and expected values and are able to describe random processes in the time and frequency domain.
- The students are able to determine the entropy of a discrete memoryless random source, construct a Huffman code and determine the redundancy of a given code.
- The students know the layout of a binary communication system in particular the layout of the optimum receiver in the presence of additive white Gaussian noise and the fundamental signaling methods for binary communications.

Contents:

Fundamental Concepts

- Information, messages and signals, requirements for communication systems,
- Advantages of digital communications, block diagram of digital communication systems,
- Simple examples of basic blocks: source, source coding, channel coding, and modulation.

Probability and Random Variables

- Short review of probability, expected values and distribution functions.

Introduction to Information Theory

- Information, redundancy, irrelevance, Huffman coding, channel capacity.

Random Processes and Noise

- Random signals, correlation functions, power density spectrum, stochastic processes and LTI systems.
- Fundamental Method for Digital Transmission
- Binary communications: optimum receiver, unipolar, bipolar and orthogonal signaling,
  continuous transmission: 1. Nyquist criterion, power density spectrum of digitally modulated signals,
  Introduction to bandpass transmission: phase shift keying.

UX: Introduction to UNIX

Professor, Unit shortcut, and Unit name: E - **W**

Grebe, UX, Introduction to UNIX
(German name: Einführung in UNIX-Systeme)

Pre-requisites:

Modules IN1 and IN2
Boole's Algebra, fundamental knowledge in design and operation of computers, programming skills (C, C++, or Java).

Learning goals:

In general; Module-specific:
- Fundamental understanding of the UNIX / Linux architecture and processing
- Knowledge of the function of concurrent processes
- Knowledge of the function of distributed processes
- Knowledge on programming methods and software engineering.
- Knowledge on programming concepts at console level / scripting

Know-how/methods/learning/social competence; Professional preparation:
- Students will learn to set up and operate Debian Linux systems
- Students will be able to work with the Debian Linux user interface
- Students will be able to develop, implement, and test bash scripts

Contents:

Unix distributions and basics
- file systems, access control, File System Hierarchy Standard (FHS),
- Kernel functions,
- Unix I/O,
- Shell functions,
- file system commands, I/O redirections, filtering commands,
- vi editor,
- basic UNIX/Linux networking configurations

Basic shell programming
- Skripting (if, else, while, for, ...),
- sed, awk, init scripts

UNIX/Linux processes and IPC
- concurrency concepts,
- processes and signals,
- scheduling and priorities,
- detailed IPCs (semaphore, message queue, shared memory, Unix-Domain sockets)

UNIX networking
- Overview on servers (e.g. APACHE, FTP, SAMBA, NFS),
- configuration of network services

VA: Vector Calculus

Professor, Unit shortcut, and Unit name: Gornik, VA, Vector Calculus (German name: Vektoranalysis)	Cg - S
Pre-requisites: MA1, MA2, LA1, LA2, GE1, GE2	
Learning goals: In general: ➢ Students will get across with advanced theoretical and mathematical methods in electrical engineering Module-specific: ➢ Students will know the method of calculating of multiple, volume, and surface integrals ➢ They will know about the fundamentals and extension of vector calculus ➢ They will know about the treatment and application of integral theorems (Gauss, Stokes) Know-how/methods learning/social competence ➢ Students will able to solve problems in electrical engineering using theoretical and mathematical methods Professional preparation: ➢ Technical and scientific work using theoretical and mathematical tools	
Contents: ➢ Introduction to treatment of Multiple Integrals ➢ Vector Calculus: two and three dimensional curves/areas in the space, Scalar and Vector Fields, Differential Operators (Gradient, Divergence, Rotation, Laplace Operator), Path, Surface and Volume Integrals ➢ Integral Theorems (Gauss, Stokes) ➢ Specific Coordinate Systems ➢ Application of the Mathematics Methods to Electromagnetic Fields	

VKS: Verification of Complex Software Systems

Professor, Unit shortcut, and Unit name: Eg - **S**
Nissen, VKS, Verification of Complex Software Systems
(German name: Verifikation komplexer Software-Systeme)

Pre-requisites:
Good programming skills
Lecture "Software Engineering"
Lecture "Methodological Fundamentals of Computer Science"

Learning goals:

In general:
- students will gather knowledge and experience in software system verification

Module-specific:
- students will know about advanced test methods, their theoretical background ant their practical application
- they will know about tasks and goals of test management
- they will know about the structure and activities of a test process
- they will be able to prepare a test concept for a complex software system
- they will be able to set up a failure management system
- they will know the test languages "UML 2 testing profile" and TTCN-3 and will be able to specify test cases in these languages
- students will be able to work with tools supporting the test activities
- they will be know about modern test strategies
- they will know about test automation

Contents:
- Introduction to system verification, the process, tasks and goals
- Advanced test methods: formal techniques, risk based testing, GUI testing
- Test management: fundamental test process, test concept, test maturity models, test metrics, test evaluation, failure management, test management tools
- Test languages: overview of test languages, structure of test systems, abstract test specifications, system test specifications
- Test tools: overview of test tools, white box testing, system testing, GUI testing
- Modern test strategies: model based testing, design for testability, test driven design, test automation

VMA: Distributed and Mobile Applications Programming

Professor, Unit shortcut, and Unit name: E - **S**

Vogt, VMA, Distributed and Mobile Applications Programming
(German name: Programmierung verteilter und mobiler Anwendungen)

Pre-requisites:
- IN1, IN2: Programming in Java SE, esp. graphical user interfaces.
- BVS1, BVS2: Programming with concurrency, esp. Java threads and sockets.
- Preferably practical experience with Eclipse.

Learning goals:
- Know software platforms for mobile devices (“smart phones”).
- Be able to write application programs for Java-ME- and Android-based devices.

Contents:
- Operating systems and programming languages for smart phones.
- General structure of Java ME and Android applications.
- Graphical user interfaces in Java ME and Android.
- Data management in Java ME (file system, record store) and Android (file system, SQLite database, content provider).
- Concurrency in Android: intents, services, AIDL, threads.
- Network communication in Java ME and Android, esp. Internet access.
- Location-based services in Java ME and Android.

WC2: Material Science and Chemistry 2

Professor, Unit shortcut, and Unit name: **?? - W**
Löbach, WC2, Material Science and Chemistry 2
(German name: Werkstoffkunde und Chemie 2)

Pre-requisites:
The lectures in chemistry will be held for beginners. There is no need for previous knowledge

Learning goals:
- Knowledge of the basic and the mean reactions both in organic and inorganic chemistry.
- Knowledge of the basic concepts in physical chemistry.

Contents:
- Inorganic Chemistry: the mass action law, the calculation of the mass action constant, oxidation and reduction, definition of acids and bases, some important acids and bases, combined reactions from acids/bases and oxidation materials or reduction materials, the Nernst Equation, electrochemical fuel cells
- Organic Chemistry: Carbohydrates with saturated or unsaturated bonds, aromatic hydrocarbons, functional groups like alcohols, amines or organic acids, carbonyl compounds like ketones or aldehydes,
- Organic reactions: esterification, electrophilic addition to multiple bonds
- Polymer chemistry: some basic polymers for use in microlithography

WDÜ: Thin Film Technology

Professor, Unit shortcut, and Unit name: E - **S**
Kohlhof, WDÜ, Thin Film Technology
(German name: Dünnschichttechnik)

Pre-requisites:
Basic knowledge in Physics and Material science

Learning goals:

In general:
- students will gather knowledge on state of the art thin film, vacuum and plasma technology and its application in daily products and processes

Module-specific:
- students will learn fundamentals and applications of the technologies

Know-how/methods/learning/social competence:
- students will learn the design, operation and maintenance of equipments and the specific application of thin films
- students will further be introduced to the production chain ranging from preparation, deposition to quality assurance
- they will practice their seminar presentation techniques

Professional preparation:
- students will learn related development efforts, covering equipment design, specific thin film adoption as well as the production chain including preparation, deposition and quality assurance

Contents:
- introduction to vacuum technology: pumping kinetics, components, operation and maintenance
- plasma technology: plasma properties, plasma generation, plasma sources
- thin film production processes: etching, deposition, diffusion, implantation and its characterization
- application of thin film technology: electronic and optical components, wear protection, compact discs, thin film solar cells

WE: Web Applications

Professor, Unit shortcut, and Unit name: E - **S**

Grebe, WE, Web Applications
(German name: Webapplikationsentwicklung)

Pre-requisites:

Boole's Algebra, basic knowledge in design and operation of computers and operating systems, experiences in OS (Linux preferred), firm programming skills (C, C++, or Java)

Learning goals:

In general & Module-specific:

- Fundamental understanding of the development of dynamic Web applications
- Knowledge on architectures and design concepts of database-based Web content and applications.
- Knowledge on programming methods and software engineering.
- Knowledge on programming concepts and programming languages for the development of Web content.

Know-how/methods/learning/social competence & Professional preparation:

- Students will be able to analyse the SW requirements for dynamic Web content
- Students will be able to design systems and software architectures for advanced Web content.
- Students will be able to implement advanced Web systems.
- Students will be able to develop and test dynamic Web applications.

Contents:

- Introduction to development concept of Web applications, fundamentals of Web design, design of Web pages, introduction to HTML and XHTML
- Browser independent system programming, introduction to Cascading Style Sheets (CSS), system optimizations, barrier-free Web content
- Development of dynamic Web pages, fundamentals of PHP, MySQL/PostgreSQL in PHP (SQL, ERD, ...), development of template systems in PHP, multi-user systems in PHP (sessions)
- Introduction to JavaScript, embedding JavaScript into HTML, comparison of HTML and JavaScript
- Fundamental of software engineering and program elements

WEG: Energy Systems

Professor, Unit shortcut, and Unit name: Schellong, WEG, Energy Systems (German name: Energiesysteme)	**?? - ??**
Pre-requisites: MA1, MA2, GE1, GE2, IN1, IN2, WRE differential and integral calculus, algorithms, basics in software engineering, heat and power generation and distribution, objectives and methods of computer aided energy management	

Learning goals:

In general:
- students will gather knowledge on energy management methods in the field of energy systems of industrial enterprises as well as of facilities and municipalities

Module-specific:
- students will know about the mathematical tools of modelling and optimizing energy systems
- they will know about the necessary informational technologies for energy data analysis
- they will know about the objectives and structure of energy management systems in industrial enterprises and in facilities
- they will learn how to analyze the energy consumption in dependence of production, climate, and facility
- they will learn how to find optimization potentials
- they will know about methods for improving the energy efficiency
- they will know tools for reducing the energy costs

Know-how/methods/learning/social competence:
- students will be able to apply the mathematical and informational tools for modelling and optimizing energy systems
- they will be able to apply suitable technologies for the reduction of energy consumption
- they will learn the interdisciplinary character of applied project work in the field energy and environmental management
- they will learn how to build up a “virtual consulting company” and to work in a project team
- they will be able to represent their results by computer aided presentations

Professional preparation:
- students can work on actual problems in the fields of energy economy, facility management, energy controlling, and portfolio management
- they have learned to apply combined methods for analyzing and optimizing industrial energy systems

Contents:
- structure of energy supply and purchase in liberalized markets
- objectives and structure of energy management systems in industrial enterprises and in facilities
- energy data analysis and energy balances
- objectives and methods of energy controlling
- energy efficiency and optimization potentials
- technologies for reducing energy consumption and their economical evaluation
- portfolio management
- energy supply concepts
- project management

WEV: Electromagnetic Compatibility

Professor, Unit shortcut, and Unit name: **?? - S**
Humpert, WEV, Electromagnetic Compatibility
(German name: Elektromagnetische Verträglichkeit)

Pre-requisites:
MA1, PH1, GE1, GE2
Mathematics; physics; electrical engineering

Learning goals:

In general:
- students will gather knowledge on fundamentals of electromagnetic influences on electrical systems

Module-specific:
- they learn to classify the electromagnetic signals
- students will be able to apply the important algorithms to process disturbance signals in time and frequency domain
- students will learn methods how to calculate a disturbance variable and how to reduce it through filtering and shielding

Know-how/methods/learning/social competence:
- students will be able to apply specific layouts to reduce disturbance variables influencing electrical devices
- they get used to the EMV-directive
- they will learn to use the knowledge of former modules in order to realize electronic products

Professional preparation:
- students learn about the importance of electromagnetic compatibility and about its legal requirements

Contents:
- definitions and legal requirements
- classification of electromagnetic signals
- mathematical methods: Fourier transform, time and frequency domain
- characteristically disturbance variables its origin, parameters, effects
- coupling ways: galvanic, capacitive, inductive, waves
- reducing of disturbance: protecting elements, filtering, shielding

WK: Material Science and Chemistry 1

Professor, Unit shortcut, and Unit name: **C - S**
Welker, WK, Material Science and Chemistry 1
(German name: Werkstoffkunde)

Pre-requisites:
PH1?, GE1?, GE2
fundamentals in physics and electrical engineering

Learning goals:

In general:
- students will gather fundamental knowledge on the composition of materials and their electrical, magnetic, and dielectric properties/characteristics

Module specific:
-

Know-how/methods/learning/social competence:
- students will learn to find and use secondary literature to gain knowledge about material science on their own
- they will learn about the specific electrical properties of the materials from their atomic composition
- they will gain profound knowledge in specific seminars

Professional preparation:
- students learn to look at materials under aspects of engineering
- they train spatial sense on crystalline structures
- they work out decision criteria for applications using simple assessments/evaluations

Contents:
- composition of materials (atoms, periodic table, chemical bonds, crystalline structures and alloys)
- fundamentals regarding module WC2/MC2: Metals, Semiconductors (composition and crystal structure, electronic band model, intrinsic- and impurity conductivity, pn-transition
- dielectric materials: (classification, dielectric polarization and loss and from those development of optical properties, comparison $\varepsilon 1$, $\varepsilon 2$ and n,k description
- magnetic material (classification, magnetization and hysteresis curve, loss mechanisms)

WL: Wavelets and their Applications to Image Processing

Professor, Unit shortcut, and Unit name: Stoffel, WL, Wavelets and their Applications to Image Processing (German name: Wavelets)	Eg - W
Pre-requisites: MA1 (Mathematics 1), MA2 (Mathematics 2), AM1 (Applied Mathematics 1), AM2 (Applied Mathematics 2), ASS (Analog Signals and Systems), DSS (Discrete Signals and Systems)	
Learning goals: Students will understand the idea of the wavelet transform and their implementation as a Filter Bank and get experience using corresponding tools on a computer.	
Contents: ➢ Filter banks and wavelets, discrete Wavelet transform, Construction of appropriate filters ➢ Lifting scheme, interpolating wavelets, two dimensional filters ➢ Image compression ➢ Denoising of image and audio data	

WMF: Micro Production Engineering

Professor, Unit shortcut, and Unit name:	?? - W
Kohlhof, WMF, Micro Production Engineering (German name: Mikrofertigungstechnik)	

Pre-requisites:
Basic knowledge in Physics and Material science

Learning goals:

In general:
- students will gather knowledge on micro systems technology as a key technology of 21st century

Module-specific:
- students will learn fundamentals, developments and applications of the technologies

Know-how/methods/learning/social competence:
- students will learn to apply software tools for micro system engineering, design and behavior simulation
- student will understand to use analogies in physics to simulate non electrical behavior of micro systems by its electrical counterpart
- students will practice the computer aided design steps of a concrete micro sensing device

Professional preparation:
- students learn to think and work interdisciplinary in fields like electrical and mechanical engineering, physics, chemistry and material science
- students learn the use of virtual engineering as an economic method for rapid prototyping
- students will be introduced in state of the art micro fabrication steps in clean rooms

Contents:
- introduction to material properties of sensing structures
- production processes like thin film technologies and micro packaging
- analogies between mechanics, fluidics, thermodynamics, waves and electrical circuits
- simulation and design platforms such as MEMSpro/SPICE, ANSYS
- state of the art micro devices in the market like airbag/acceleration sensor, valves, climate sensor

WO: Wave Optics

Professor, Unit shortcut, and Unit name: **C - W**
(NF Gutjahr), WO, Wave Optics
(German name: Wellenoptik)

Pre-requisites:
MA1, MA2, GO
Integrals; Derivatives; trigonometric, exponential, limits; series; complex numbers; Fourier series; geometrical optics

Learning goals:

In general:
- Students learn how to describe light as a wave

Module-specific:
- students will learn to understand the effects of light that can only be described by using the wave model
- they will learn the fundamental concepts of wave optics
- they will learn the practical use of these basics

Know-how/methods/learning/social competence:
- the students will learn to deal with interference, diffraction, coherence and polarization
- they will gather practical experience with interferometers, diffraction, coherence, polarization
- they will learn theoretically and practically on Fourier optics

Professional preparation:
- the students will learn if light has to be described as a wave or not

Contents:
- mathematical description of light as wave
- superposition of waves, interference, two beam interference, interferometers (Michelson, Twyman green, Mach Zehnder ....)
- multiple beam interference, Fabry Perot interferometer, optical coatings
- diffraction, Hygens' principle, Fresnel diffraction / Fraunhofer diffraction, diffraction of a slit, double slit, circular aperture, diffraction with gratings, zoneplates, Babinet's principle
- polarization, mathematical description of the different states of polarization, dichroism, polarizer, birefringence, wave plates, Fresnel's formula for reflection, Brewster's law
- coherence of light (spatial, temporal), coherence function as the Fourier transform of the distribution functions
- Fourier optics

WRE: Computer Aided Energy Management

Professor, Unit shortcut, and Unit name: **?? - ??**
Schellong, WRE, Computer Aided Energy Management
(German name: Rechnergestütztes Energiemanagement)

Pre-requisites:
MA1, MA2, GE1, GE2, IN1, IN2
differential and integral calculus, algorithms, basics in software engineering, heat and power generation and distribution, power plant technologies

Learning goals:

In general:
- students will gather knowledge on energy management methods in the field of energy supply including application in energy economy

Module-specific:
- students will know about the mathematical tools of modelling and optimizing energy systems
- they will know about the necessary informational technologies to built up an energy management system
- they will know about the goals and structure of energy management systems
- they will know about the fundamentals of the power supply structure in liberalized markets
- they will know the advantages of cogeneration of power and heat for sustainable development
- they will know the complex structure of the optimization problem for minimizing supply costs
- they will know optimization strategies

Know-how/methods/learning/social competence:
- students will be able to apply the mathematical and informational tools for modelling and optimizing energy systems
- they will be able to analyze the technical, economical and informational framework conditions of energy supply
- they will learn the interdisciplinary character of applied project work
- they will be able to work in a project team
- they will be able to represent their results by computer aided presentations

Professional preparation:
- students can work on actual problems of energy economy
- they have learned to apply combined methods for modelling and optimizing technical and economical energy systems

Contents:
- structure of energy supply in liberalized markets
- objectives and structure of energy management systems
- energy data analysis
- mathematical modelling of energy systems by regression analysis (cogeneration systems)
- forecast of energy demand (regression models and artificial neural networks)
- economical relationships between power generation, distribution, and purchase
- functions and methods of the energy stock exchange
- optimization strategies

ZR: State Space Control

Professor, Unit shortcut, and Unit name: **Eg - S**

Große, ZR, State Space Control
(German name: Zustandsregelung)

Pre-requisites:
ASS, DSS, RT1
Basic and extended knowledge about control systems in theory and application

Learning goals:

In general:

- students will gather knowledge in state space modelling and time-discrete systems in time domain and z-transformation.

Contents:

- Discrete-time description of dynamic systems,
- Solving difference equations using z-transformation,
- State space models,
- Controllability, observability,
- State space controller in time domain,
- Simulation,
- Observer,
- Output feedback,
- Controller design with pole placement,
- Optimal control and
- Frequency domain description