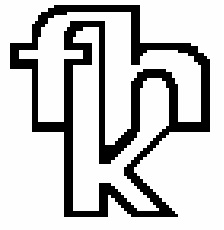

FACHHOCHSCHULE KONSTANZ

Faculty

Electrical Engineering

Degree Course Scheme
and
Course of Studies

Electrical Energy- and Automation

Date: 17.01.1998

Following are described the courses of studies with the contents of the lectures on Electrical Energy and Automation

The specified courses of studies are an extract of the currently valid conditions of study and examination rules.

The contents are listed in alphabetic order.

Courses of Study Electrical Energy and Automation

Term	1	2	3	4	5	6	7	8	
	Basic Studies			Main Studies					
Subject	Hours per week (SWS)								Sum
Mathematics 1,2,3	8	8		(2)					16+(2)
Physics 1,2,L	4	2+2L							8
Engineering Mechanics 1,2	4	2							6
Materials for Electrical Engineering		4							4
Principles of Electrical Engineering 1	6								6
Principles of Electrical Engineering 2	6								6
Theory of Alternating Current 1,2		6		2					8
Electrical Metrology 1,2,L		2		4+2L					8
Digital Technology 1,L				4	2L				6
Theory of Design			2						2
Thermodynamics				2					2
Data Processing 1,L1,L2		4		2L			2L		6+(2)
Electronics 1,2,L				4	4+2L				10
Microcomputer Technology 1,L					4		(2)		4+(2)
Electrical Engines 1,2,3				4	2		2		8
Electrical-Drive Engineering 1,2					4		2		6
Power Electronics 1,2					4		2		6
Energy Conversion L1,L2							2L	(4L)	2+(4)
Electrical Energy Supply 1,2,3					2		4	(2)	6+(2)
High Voltage Engineering 1,2,L							4	(2+2L)	4+(4)
Electrical Power Stations							2		2
Control Engineering 1,2,L				4	2		2L		8
Digital Control Systems								(2)	(2)
Process Automation								4	4
Sensor Technology							2		2
Renewable Energy								(2)	(2)
Power Economics								(2)	(2)
Lightning Engineering					(2)				(2)
Electrochemistry		(2)							(2)
Business Economics								2	2
Economics				2					2
Management-Theory								(2)	(2)
Ergonomics				(2)					(2)
Projectmanagement							(2)		(2)
CAE, Computer Aided Engineering							(2)		(2)
SPS, Programmable Logic Controller					(2)				(2)
Installation Techniques							(2)		(2)
Environmental Technology								(2)	(2)
Law					(2)				(2)
Technical English	(2)								(2)
Colloquium for final thesis								2	2
Final Thesis									
Weekly hours of compulsory subjects:	28	30	2	30	26		22	8	162
Weekly hours of elective subjects:	(2)	(2)		(4)	(6)		(10)	(20)	(44)

Explication:

Semester-periods-per-week in parenthesis are Elective-Subjects.
Election of Elective-Subjects is recommended but not obliged. L means Laboratory.

In total at least 16 Semester-periods-per-week have to be accomplished.

Table of contents

Electrical-Drive-Engineering 1

Term:	EE5
Semester periods per week:	4 SWS
Type:	Lecture
Verification:	Written examination, 135 min.

Contents:

1. Introduction and conceptual formulation
2. Movement and adjustment
3. Assembly and set-up of an arrangement with electrical drives
4. Measuring arrangement
5. Direct current shunt-wound machine
6. Direct current series-wound machine
7. Brush-less direct current machine
8. Synchronous servo drives

Lecture is supplemented with exercises.

Electrical-Drive-Engineering 2

Term:	EE7
Semester periods per week:	2 SWS
Type:	Lecture
Verification:	Interdisciplinary written examination “Converter-drives”

Contents:

Annotation: Lecture is continuation of “Electrical-Drive-Engineering 2”

1. Converter-drives with asynchronous machines
   - Three phase AC-controller
   - Subsynchronous converter cascade (static Kraemer drive)
   - Double fed motor
   - Frequency converter with constant-voltage DC link
   - Frequency converter with DC link

2. Converter drives with synchronous machines
   - Converter fed motor

3. Control in drive engineering
   - Dynamic behaviour of DC machines
   - Cascade control
   - Dynamic behaviour of AC machines
   - Space-vector
   - Main-feature of field-orientated control

Lecture is supplemented with exercises.

Ergonomics

Term:	EE8
Semester periods per week:	2 SWS
Type:	Lecture
Verification:	Presentation

Contents:

1. Fundamentals
   - Fundamentals of ergonomics
   - Methods of Ergonomics

2. Human motivation and capacity
   - Maslow's hierarchy of needs
   - Application to formation of work

3. Models of organisation and capacity
   - Hierarchy models
   - Group work
   - Project-teams

4. Application: Lean-Management
   - Conception and philosophy of Lean-Management
   - What is quality?
   - Value-chain and networks
   - Super-networks
   - Techniques of networks

5. Lean-Management in “Baden-Württemberg” (State in Germany)
   - Lean-Management in middle enterprises?

Lecture is supplemented with case studies.

Educational objective:

- Understanding of context in organisation and efficiency
- Understanding that quality is a customer orientated term
- Awareness of modern work-concepts

Economics

Term:	EE8
Semester periods per week:	2 SWS
Type:	Lecture
Verification:	Written examination, 135 min.

Contents:

1. Introduction to Accounting
   - Accounting as an instrument of management
   - Significance of Accounting for management
   - Tasks and objective of Accounting

2. Defining costs
   - What are costs?
   - Costs, expense, expenditure
   - Structuring of costs
   - Average costs
   - Marginal costs

3. Organisational accounting
   - Organisational accounting - introduction
   - Objective of organisational accounting
   - Calculating cost categories (amount and tracking)
   - Cost centre accounting
   - Cost centre definition
   - Objective of cost centre accounting
   - Internal commissioning
   - Cost tracking sheet (ger.: Betriebsabrechnungsbogen (BAB))
   - Production equipment rate calculation

4. Calculation (Cost owner centred calculation)
   - Conception and objective of calculation
   - Pre- and post-calculation
   - Main forms of calculation
   - Calculation by division
   - Surcharge calculation

5. Additional developments in Accounting
   - Absorption costing / Partial costing
   - Profit margin
   - Development to target costing
   - Basic approaches of Cost-Account for new technologies (CIM)

Due to the limited time for the subject of Business-Economics only the Accounting is being taught with which the engineer will be confronted in his future carrier.

CAE, Computer Aided Engineering

Term:	EE7
Semester periods per week:	2 SWS
Type:	Laboratory
Verification:	Student research project

Contents (in parenthesis number of lessons):

1. Principles of development of a new product (2)
2. CAE: What, why, how? (2)
3. The Software “Design-Centre” (2)
4. Possible analysis of circuits (4)
5. Introduction in the hierarchical design of electronic circuits (4)
6. Integration of models with floppy and internet, respectively (2)
7. From circuit design to finished printed circuit board (PCB) (2)
8. Introduction to simulation of complex systems (2)

At the beginning of each lesson an introduction to the subject takes place, then the student has to work on examples.

Educational Objective:

- Understanding for assignment of CAE-Tools
- Development of circuits and simulation from the idea and the specification to the final printed-circuit-board.
- Insight to functioning

Data Processing 1

Term:	EE7
Semester periods per week:	4 SWS
Type:	Lecture
Verification:	Written examination, 135 min.

Contents (in parenthesis number of lessons):

1. Introduction (6)
   - Development of calculating machines
   - Program languages, Programming flow chart (structure chart)
   - Introduction in MS-DOS
   - Program development

2. Fundamentals of C-Programming (6)
   - Structure of C-Programs
   - Constants and variables, data types, numbering systems
   - Input/output of data

3. Operators in C (6)
   - Arithmetic operators, increment-/decrement-operators
   - Compare-operators, logical operators, allocating operators

4. Control instructions in C (6)
   - if-, switch-, while-, do…while-, for-instruction
   - Supplementation

5. Arrays (6)
   - One-dimensional and multidimensional arrays
   - Examples for instructions with arrays

6. Functions (6)
   - Definition and declaration of functions
   - Global and local declarations
   - Functions with and without return-values
   - Handing over of arrays to functions

7. Pointer (6)
   - Addressing of data
   - Declaration and usage of pointer

The lecture is being supplemented with practical exercises with PC (20).

Educational Objective:

- Get to know fundamental terms of data processing, acquire PC-skills
- Programming flow charts with structure chart
- Development of programs in C-language
- Introduction in vector- and matrix-algebra with application of system of equation
- Application of differential calculation and polynom-arithmetic

Data Processing – Laboratory 1

Term:	EE4
Semester periods per week:	2 SWS
Type:	Laboratory
Verification:	Project with colloquium at end

Contents:

Project with Software-Development in high-level programming language (C++) at Personal Computer in groups of 2.

Typical topics:
- Development environment: Guidelines for Code-generation, Project handling, Debugging
- Calculation of electronic formulas and processes
- In- and Output of data
- Graphic- / Mouse-functions
- Data-Transmission via serial interface

Processing of topics takes place as follows
- Introduction in discrete Software-aspects
- Presentation of project
- Autonomous solving of exercise
- Discussion and Colloquium of solved exercise

Educational Objective:

- Deepening of already attained knowledge in a high-level programming language
- Development in projects of programs in the field of electrical energy and automation

Data Processing – Laboratory 2

Term:	EE7
Semester periods per week:	2 SWS
Type:	Laboratory (Elective-Subjects)
Verification:	Project in Laboratory, Student research project

Contents (in parenthesis number of lessons):

Special topics on agreement, e.g.
- Object orientated Programming in C++
- Software-Engineering
- UNIX-Workstations
- Databases
- Expert systems
- Neuronal networks
- Fuzzy-Logic
- Mathematics-Systems (Maple, Mathematica, MathCAD)
- Algorithms for numerical Mathematics

For verification of this lecture the student has to work on a Student research project and its presentation.

Educational Objective:

- Creation of deep knowledge in a special field of data-technique
- Expansion of ability in presentation techniques

Digital Control Systems

Term:	EE8
Semester periods per week:	2 SWS
Type:	Lecture, Laboratory
Verification:	Student research project, Project in Laboratory

Contents:

1. Mounting of a digital control circuit with a speed controller as an example
2. Direct signals
   - Series of impulses and numbers
   - Analogue-Digital- and Digital-Analogue-converter
3. Design of a digital controller
   - Quasi-continuous digital controlling
   - Algorithms of P-, PI-, PID-controllers
4. Mathematical description of a sampling controller
   - Differential equations
   - Z-Transformation
   - Z-Transfer-function
   - Direct filter
5. Realisation of a digital controller with a microcontroller
   - PID-positioning- and velocity-algorithms
   - Choice of sampling interval
   - Choice of word-length of digital values
   - Choice of word-length of AD- and DA-converters
6. Information-loss with digitalisation
   - Nyquist-Frequency
   - Sampling-theorem according to Shannon
7. Numerical and algorithmic problems with calculation of PID-algorithm
   - Trimming of word-lengths
   - Integral offset
   - Hitchless operation of actuator
   - Consideration of restriction of regulating variable

This lecture is being supplemented by hardware and software projects.

Educational Objective:

- Digitalisation of continuous measuring signals and measure of information-loss
- Mathematical description of discrete signals
- Practical realisation of digital control loop with microcontroller

Digital Technology 1, Laboratory

Term:	EE4, EE5
Semester periods per week:	4 SWS, 2SWS
Type:	Lecture, Laboratory
Verification:	Written examination, 135 min.

Contents (in parenthesis number of lessons):

1. Numbering systems (2)
   - Systems with positional weight, polyadical numbering systems
   - Conversion of numbers of different systems
   - Handling of signed numbers
   - Arithmetic in the dual system
2. Physical presentation of data (8)
   - Analogue and digital presentation
   - Digital graphical symbols and circuit engineering (TTL- and CMOS)
3. Logic algebra (8)
   - Logic variables and functions
   - Boolean logic with combination element and calculation rules
   - Canonical form (Normal form)
   - Simplification of logical functions and circuits
4. Codes (6)
   - Numerical codes, testable codes, correctable codes
   - Alphanumerical codes
5. Combination circuits (10)
   - Number-Comparator, multiplexer, demultiplexer
   - Adder, subtractor, multiplicator
   - Code-converter, coder, decoder
6. Elements
   - Flipflops, Monoflops
   - Astable elements
7. Switching elements
   - Structure of switching elements
   - Switching sequence diagram, switching sequence table
   - Transient- and output-functions
   - Switching elements with synchronous operating mode, synchronous counter
   - Register, shift register, frequency divider
   - Switching elements with asynchronous operating mode, asynchronous counter

This lecture is being supplemented with exercises (8). The knowledge is being deepened with experiments in the digital-laboratory (30).

Educational Objective:
- Understanding of logical context
- Capability to associate with digital circuits
- Development of digital circuits

Electrical Energy Supply 1

Term:	EE5
Semester periods per week:	2SWS
Type:	Lecture, Laboratory
Verification:	See Electrical-Energy-Supply 2

Contents:

1. Terms: values, norms, regulations, literature

2. Electrotechnical and mathematical fundamentals for description of the operating characteristics of three-phase equipment and three-phase nets.

3. Three-phase transmission-nets and distribution-nets
   - Formation and structure of nets of public and industrial power supply
   - Net-forms, Neutral-earthing

4. Equipment of three-phase-nets 1
   - Net-feed, cable, overhead-wire, distribution-transformer
   - Rating data, equivalent circuit, operating characteristics

5. Calculation of stationary operation in radial- and ring-nets
   - Description of Feed-out (net-loads) and feeds (generators)
   - Voltage-drop, capacity utilisation, transmition-loss, efficiency-factor
   - Voltage-dependency of net-load
   - Application-oriented energy-flow calculation with Software “NetCal”

6. Short circuit close and far to generator
   - Terms, short circuit parameters line-diagram of currents
   - Determination of short circuit values according to DIN VDE 0102/01.90

Deepening of knowledge with 10 exercises from projects in practice.

Educational Objective:
See Electrical-Energy-Supply-2

Electrical Energy Supply 2

Term:	EE7
Semester periods per week:	4SWS
Type:	Lecture, Laboratory
Verification:	Written examination, 135 min. (Electrical-Energy-Supply 1/2)

Contents:

1. Calculation of energy-flow with computer program
   - Goal, undertaking, description of node-type
   - System of equation: Description of stationary, complex energy-flow
   - Algorithm for solving of energy-flow
   - Application-orientated energy-flow -calculation with Software “NetCal”
2. Equipment of three-phase-nets 2
   - Asynchronous machine, two-winding- and three-winding-transformer
   - Rating data, equivalent circuit, operating characteristics
3. Disturbance to three-phase-nets
   - Voltage-alteration due to starting of asynchronous machine
   - Reactive power and its compensation with machines and transformers
   - Harmonics of power-electronic-equipment
4. Calculation of short circuit current in three-phase-nets according to DIN VDE 0102/01.90
   - Meaning of short circuit currents, fault-types, terms, parameters
   - Calculation-methods, system of equations, solving-algorithms
   - Derivation and application of symmetric components (transformation-equations, measuring arrangement for impedance in 012-system, equivalent circuits of equipment in 012-system, transmission of component-currents
   - Asymmetric short circuits
   - Application-orientated short-circuit-calculation with Software “NetCal”
5. Preservation-action in low- and middle-voltage-nets

Deepening of knowledge with 20 exercises from projects in practice.

Educational Objective:

- Understanding and emulating operative characteristics of electrical equipment in three-phase-nets based on rating data,
- Planing of electrical-installation and nets according to state of the art (Norms) and assessment of technical quality,
- Understanding, application Software for net-calculation (energy-flow, short circuit currents, net-disturbances due to harmonics) for decision making.

Electrical Energy Supply 3

Term:	EE8
Semester periods per week:	2SWS
Type:	Seminar
Verification:	Written examination, 90 min.

Contents:

1. Earthing in electrical power installations

2. Star point in three phase nets
   - Insulated star point
   - Ground-fault-neutraliser-grounded system
   - Low-resistance star point earthing

3. Project orientated calculation of short circuit currents in three phase nets
   - Generators with direct supply connecting
   - Generators and unit-transformer of power unit
   - Influence of engines
   - Phase-Earth-Phase-fault

4. Designing of power installations in regards to mechanical and thermal short-circuit-strength in accordance with DIN VDE 0103/04.88

6. Switching device and power-system-protection in middle- and high-voltage-nets

Deepening of knowledge with autonomous resolution of a project in practice with a team, using software-system “NetCal” as a working- and decision-finding-tool.

Educational Objective:
- Systematical comprehension of deepened knowledge for understanding of the operational behaviour of three-phase-nets,
- Reading and understanding of technical norms with application to technical cases.

Electrical Engines 1

Term:	EE4
Semester periods per week:	4SWS
Type:	Lecture
Verification:	Written examination, 135 min.

Contents:

1. Basics
   - Overview of electrical machines and its modes of action
   - Basic laws
   - Materials
   - Loss and efficiency factor
   - Heating, temperature rise
   - Operation mode

2. DC-machine (Electrical Engines 1)
   - Structure, modes of action, equations and control of shunt-wound machine
   - Structure, modes of action, equations and control of series-wound machine

3. Transformer (Electrical Engines 1)
   - Structure, modes of action, equations and control of single-phase-transformer
   - Structure, modes of action, equations and control of three-phase-transformer

Lecture is supplemented with exercises.

Educational Objective:
- Understanding of modes of action and operational behaviour of electrical engines with basic types of construction
- Capability of choice of electrical engines for different applications
- Capability of rapid and rough dimensioning of electrical engines

Electrical Engines 2

Term:	EE5
Semester periods per week:	2SWS
Type:	Lecture
Verification:	Written examination. Electrical Engines 2+3, 90 min. with the framework of examination of power-converters

Contents:

1. Asynchronous machine
   - Fundamental knowledge of theory of rotating field and winding for rotating field
   - Three-phase asynchronous machine with squirrel-cage rotor (cage rotor) (Structure, modes of action, equations, mode of operation and control)
   - Three-phase asynchronous machine with wound-rotor rotor (slip-ring rotor) (Structure, modes of action, equations, mode of operation and control)
   - Linear motor (Structure and modes of action)
   - One-phase asynchronous machine (Structure, modes of action, equations, mode of operation and control)

Lecture is supplemented with exercises.

Educational Objective:
- Understanding of modes of action and operational behaviour of electrical engines with basic types of construction
- Capability of choice of electrical engines for different applications
- Capability of rapid and rough dimensioning of electrical engines

Electrical Engines 3

Term:	EE7
Semester periods per week:	2SWS
Type:	Lecture
Verification:	Written examination. Electrical Engines 2+3, 90 min. with the framework of examination of power-converters

Contents:

1. Synchronous machine
   - Cylindrical-rotor machine
     Structure, modes of action, equations, mode of operation and control
   - Salient-pole machine
     Structure and modes of operation
   - Special type of destruction
   - Dynamic of electrical machines
     Fundamentals

Lecture is supplemented with exercises.

Educational Objective:

- Understanding of modes of action and operational behaviour of electrical engines with basic types of construction
- Capability of choice of electrical engines for different applications
- Capability of rapid and rough dimensioning of electrical engines

Electrical Metrology 1

Term:	EE2
Semester periods per week:	2SWS
Type:	Lecture
Verification:	Written examination together with "Theory of alternating current 1"

Contents (in parenthesis number of lessons):

1. Fundamentals (14)
   - Fundamental terms, unit of measurement
   - Analogous- and digital measuring devices
   - Static and dynamic behaviour
   - Systematic and random errors, error propagation
   - Confidence interval, certainty of prediction
   - Structures of measuring devices

2. Measurement of current and voltage (14)
   - Permanent-magnet moving-coil instrument, quotientmeter, moving-magnet instrument, electrodynamics instrument, moving-iron instrument
   - Internal impedance, expansion of effective range, overload protection
   - Measurement of alternating current and voltage
   - Vertex, rectifying value, root-mean-square value real root-mean-square value
   - Current transformer, voltage transformer
   - Direct-voltage compensation, direct-current compensation, alternating-voltage compensation

Exercises (2)

Educational Objective:
- Capability of systematic error discussion and usage of fundamental error calculation
- Characterisation of measurement instruments and the fundamental behaviour of structure of measurements
- Knowledge of design of electromagnetic measurement instruments and usage for measurement of direct and alternating quantities

Electrical Metrology 2

Term: EE4
Semester periods per week: 4SWS
Type: Lecture
Verification: Written examination135min.

Contents (in parenthesis number of lessons):

1. Recording and storing measurement instruments (8)
   - Cathode-ray oscilloscope, storage oscilloscope, transient storage, magnetic tape recorder, Recording instrument
2. Wattmeter (8)
   - Wattmeter, Hall-wattmeter, real power, reactive power, apparent (complex) power, measurement in three phase nets (three- and four-wire nets) with symmetric and asymmetric load, Two-wattmeter circuit (Aron-circuit), power factor, phase angle
3. Energy measurement (2)
   - Motor meter, electrodynamics motor meter, induction meter
4. Measurement of ohmic resistances (7)
   - Current- and voltage-correct circuit, comparison with reference-resistor, Wheatsone bridge, Thomson bridge, insulating resistances, fault-location in cables, ground resistance
5. Measurement of reactance (8)
   - Inductance, capacitance, mutual inductance, Wien bridge, Maxwell bridge, Maxwell-Wien bridge, Schering bridge, phase-shifter bridge
6. Frequency measurement (3)
   - Pointer-type frequency meter, digital frequency measurement, quantizing error, frequency-voltage converter, time-interval measurement, reciprocal counter
7. Measurement of magnetic values (3)
   - Magnetic flow, spread, inductance, magnetisation curve, hysteresis loss, eddy-current loss
8. Instrument amplifier (22)
   - Operational amplifier, negative feedback, voltage amplifier, current amplifier, constant voltage- and current source, isolation amplifier, buffer inverter, adder, subtractor, multiplicator, root-extractor, differentiator, integrator, logarithmation module, Offset-error, thermo-electromotive force, noise, modulation amplifier, amplifier in sensor technology

Exercises (3)

Educational Objective:
- Get to know measurement methods and measurement instruments for electrical measured quantity
- Construction of measurement amplifiers corresponding to problem
- Conceptualisation of measurement installation with sensor technology

Electrical Metrology Laboratory

Term: EE4
Semester periods per week: 6 Experiments
Type: Laboratory
Verification: Laboratory - Examination 60min.

Contents:

1. Measurement of root-mean-square value
2. Oscilloscope
3. Measurement of ohmic resistances
4. Two-wattmeter circuit (Aron-circuit)
5. Measurement of inductive resistances
6. Computer controlled test bench of small-power engine

Educational Objective:

- Completion of theoretical knowledge with practical experiences
- Experiences in usage of most important measurement instruments and measurement methods
- Insight in modern automatic measurement techniques

Power Economics

Term: EE8
Semester periods per week: 2SWS (in blocks of 14 days)
Type: Seminar with group-work
Verification: Homework (written elaboration) with lecture

Contents:

1. Introduction
   Particularities of power economics, historical development with actual structure of power economics in Germany
2. Consumption of electrical energy
   Energy-flow chart, development of energy-consumption, load profile versus time
3. Supply of primary energy and resources
   Thermal, mechanical and renewable energy supplies, resources and duration
4. Power stations
   Energy balance and efficiency, thermal power stations, mechanical power stations, influence on environment
5. Transmission and distribution of energy
   Development of electrical nets, three-phase techniques, HV DCT(High-Voltage DC transmission), influence on environment
6. Energy savings
7. Costs of electrical energy
   Cost structure, fixed costs, variable costs, investment calculation and economy calculation
8. Power supply operation and interconnected operation
9. Legal general conditions
   Laws in power economics, Antitrust law, concession contracts, federal regulation on electricity tariffs “Bundestarifordnung”, general supply conditions
10. Tariffs
    Cost unit calculation, cost objective calculation
11. Competition in power economics

Educational Objective:

- Systematic documentation and oral presentation of topics in the field of electrical power economics
- Acquisition of fundamental knowledge of electrical power economics
- Investment calculation and economy calculation
- Ability of cost orientated thinking

Electrochemistry

Term:	EE2
Semester periods per week:	2SWS
Type:	Lecture
Verification:	Written examination, 90 min.

Contents:

1. Atom model (6)
   - Periodic Table of the Elements
   - Chemical bonds

2. Thermodynamic of reactions (2)
   - Kinetics of reaction

3. Acids and bases (10)
   - Protolytic equilibrium of water
   - pH-value measurement
   - Buffering curve
   - Ampholyts

4. Redox-reaction
   - Normal-hydroxen-electrode
   - Nernst-equations
   - Metals in acids

5. Miscellaneous
   - Nomenclature
   - Calculation of quantities

The lecture is being supplemented with exercises (2) and experiments.

Educational Objective:
- Understanding of fundamental chemical reactions
- Calculation of acid/base-reactions
- Electrochemical reactions

Electronics 1, 2, Laboratory

Term:	EE4, EE5
Semester periods per week:	4SWS, 4 + 2SWS
Type:	Lecture, Laboratory
Verification:	Written examination, 180 min.

Contents (in parenthesis number of lessons):

1. Introduction in fundamentals of semiconductors (8)
   - Mechanism of conduction, intrinsic conduction, extrinsic conduction
   - Electro-theoretical interpretation of current in metals and semiconductors
   - PN-junction, diode characteristic
2. Semiconductor diodes (14)
   - Break-down voltage, temperature dependency
   - Zener-diode, photodiode, photo-element, Solar cells
3. Bipolar transistor (24)
   - Structure and modes of action, current and voltage relations, physical equivalent circuit
   - Operation area, input characteristics, output characteristics
   - Setting of working point, stabilisation of working point
   - Amplifier-mode, basic circuits, negative feedback
   - Constant current supply, differential amplifier
   - Switching-mode, static and dynamic behaviour
4. Field-effect Transistor (24)
   - Types of Field-effect transistors, structure, mode of action
   - Characteristics, physical equivalent circuit, setting of working point
   - Basic circuits, amplifier-mode
   - Constant current supply, voltage controlled resistor
   - Switching-mode, static and dynamic behaviour
5. Operational amplifier (30)
   - Characteristics
   - Amplifier with feedback-loop, inverted and not-inverted amplifier
   - Analogous arithmetic circuits, adder-subtracter, subtracter, exponential amplifier, logarithmatic module, integrator, differentiator, PI-controller, PD-controller, PID-controller
   - Constant current supply, rectifier circuit
   - Maximum-demand memory, momentary-demand memory
   - Voltage-comparator, Schmitt-Trigger (threshold-detector) multivibrator

The lecture is being supplemented with exercises (20). Obtained knowledge of lecture is being deepened with experiments in the electronic laboratory. Experiments are on diode-, transistor- and operational-amplifier-circuits (30).

Educational Objective:
- Understanding for direct- and alternating-current behaviour of non-linear devices
- Application of characteristic curves and equivalent circuits of non-linear devices
- Development and design of electronic circuits

Energy Conversion Laboratory 1

Term:	EE7
Semester periods per week:	2SWS
Type:	Laboratory
Verification:	Laboratory experiments during term with final presentation

Contents (in parenthesis number of lessons):

1. Direct current engine (6)
   - Resistance test
   - Load- and open-circuit-test
   - Limiting curve

2. Three-phase transformer (6)
   - Resistance test
   - No-load-, short-circuit- and load-test
   - Determination of connection symbol and distinctive number

3. Asynchronous machine for 50Hz net (6)
   - Resistance test
   - No-load-, short-circuit- and load-test

4. Asynchronous machine with frequency converter (6)
   - Parameterisation of frequency converter
   - Commission
   - Behaviour under load and overload
   - Standard-functions of frequency converter

5. Synchronous machine (6)
   - No-load characteristic
   - Isolated operation
   - Synchronisation on 50Hz net
   - Operation with fixed net

The projects are performed in groups. Alternative or in addition to the experiments it is possible to realise an Student research project in the field of protection / control / automation of electrical engines.

Educational Objective:
- Understanding through experiments with operation of important electrical machines (energy converter)
- Documentation of experimental set-up with measurement results

Energy Conversion Laboratory 2

Term:	EE8
Semester periods per week:	4SWS
Type:	Laboratory
Verification:	Student research project, Laboratory experiments

Contents:

1. Dimensioning of energy converters
   - Finite element programs
     Calculation of:
     Magnetic fields
     Thermal fields
     Mechanical tension fields
     Linked fields

2. Control, supervision and protection of energy converters
   - PC-measurement techniques
   - Modern sensor technique and actuators
   - Process-data-manipulation
   - Process-visualisation
   - Control and Control with feedback-loop

3. Wind power station
   - Analysis of various concepts
     Plants with fixed revolutions per minute
     Plants with variable revolutions per minute
     System optimisation
     Control with feedback-loop, monitoring and protection

Educational Objective:
- Application of modern resources for dimensioning and simulation of various energy converters with respect to praxis
- Solving problems in automation with energy converters
- Optimisation of plants with utilisation of renewable energy

Renewable Energy

Term:	EE8
Semester periods per week:	2SWS
Type:	Lecture
Verification:	Written examination, 90 min.

Contents:

1. Renewable Energies
   - Alternatives for energy supply
   - Possible contribution of renewable energy
   - Water power
   - Wind power
   - Biomass-energy
   - Energy out of rubbish/litter
   - Solar-Energy

2. Distributed combined-heat-and-power (c.h.p.)
   - Energy-model in comparison
   - Fundamentals of combined-heat-and-power
   - Heat-pump technique
   - Combined-heat-and-power with motors and turbines
   - Emission and Immission

The lecture is supplemented by an excursion.

Educational Objective:
- Alternative in energy supply and its application
- Principals of distributed combined-heat-and-power

Management-Theory

Term:	EE8
Semester periods per week:	2SWS
Type:	Lecture (with praxis-oriented exercises)
Verification:	Lecture / Presentation

Contents:

1. Fundamentals

2. Human needs

3. "Leadership" in theory
   - Ideals and norms
   - Strategies
   - Instruments

4. "Leadership" in different praxis-oriented contexts
   - Industry companies
   - Service providing companies
   - Non-profit-organisations

Educational Objective:
- Overview of fundamental and also special actual topics in leadership
- Further development of proper behaviour with praxis-orientated exercises

Principles of Electrical Engineering 1

Term:	EE1
Semester periods per week:	6SWS
Type:	Lecture
Verification	Written examination, 135min.

Contents (in parenthesis number of lessons):

1. Networks (36)
   - Fundamentals, ohmic law
   - Equivalent circuit, Kirhoff-laws
   - Series- and parallel circuit of two-terminal-components
   - Power and work, network-conversion, superposition theorem
   - Equivalent voltage source

2. Stationary electrical fields (16)
   - Fundamentals, field-strength distribution along boundary layers
   - Calculation of spherical- and cylindrically symmetric fields

3. Electrostatic fields (26)
   - Fundamentals, Gaussian theorem, Coulomb laws
   - Calculation of capacitance
   - Series- and parallel circuits of capacitors
   - Field-strength distribution along boundary layers, electrical energy
   - Force due to energy conservation law

This lecture is being supplemented with exercises (18)

Educational Objective:
- Capability to calculate Direct-Current networks
- Knowledge of fundamental terms of vector- and potential fields
- Capability to solve simple problems in grounding- and high-voltage-systems

Principles of Electrical Engineering 2

Term:	EE1
Semester periods per week:	6SWS
Type:	Lecture
Verification	Written examination, 135min.

Contents (in parenthesis number of lessons):

1. Magnetic fields (78)
   - Fundamentals, Lorentz-force (electrodynamic force) Ampere's law
   - Calculation of magnetic fields in one-material medium
   - Field-strength distribution along boundary layers
   - Ferromagnetic materials, calculation of magnetic circuits
   - Faraday's law (second circuital law), self-inductance, mutual inductance, tranformer
   - Magnetic energy, force due to energy conservation law

This lecture is being supplemented with exercises (18)

Educational Objective:
- Knowledge of vector-field
- Capability to calculate forces between to parallel conductors, Direct-current-excited magnetic circuits and induced voltages and currents
- Capability to calculate networks with inductance and mutual inductance

High Voltage Engineering 1

Term:	EE7
Semester periods per week:	4SWS
Type:	Lecture and exercises
Verification	Written examination, 135min.

Contents:

1. Introduction in High Voltage Engineering
   Exercises, applications and perspectives
2. Electrical field
   - Electrical field strength, electrical potential and voltage
   - Examples of electrical fields
   - Coulomb's law
   - Space-charge
   - Energy and force
   - Polarisation
   - Dielectric loss
   - Field lines along boundary layers (calculation)
   - Calculation of electrical fields: graphical method, Measurement-bridge with Equipotential-lines, application of 4th Maxwell's equations in integral-form, Poisson's and Laplace's differential equations, numerical methods (differential method, equivalent circuit method, finite elements), utilisation-factor (due to Schwaiger), layered dielectrics.
3. Safety rules (preparation for laboratory)
4. Generation of high voltage
   - Direct voltage
   - Alternating voltage
   - Impulse voltage (impulse current)
5. Measurement techniques for high voltage
   - Measurement of high voltage (and current)
   - Loss-tangent test (dissipation-factor test)
   - Partial-discharge measurement
6. Travelling waves
7. Disruptive discharge / flashover in gases, liquids and rigid insulating materials

Lecture and exercises are being supplemented with a demonstrations in the high-voltage laboratory and a experiment.

Educational Objective:
- Knowledge of application of high-voltage technique
- Fundamentals in high-voltage technique
- Knowledge of actual areas of high-voltage technique

High Voltage Engineering 2

Term:	EE8
Semester periods per week:	2SWS
Type:	Lecture
Verification	Student research project

Contents:

1. Determination of electrical fields
   - Calculation methods
   - Optimisation
   - Examples of Constructions

2. Standards and guidelines
   - VDE-standards (VDE = Verband Deutscher Elektrotechniker)
   - Accident prevention regulations
   - Installation of test-setups
   - Safety devices

3. Generation and measurement of high alternating voltages
   - Mode of operation of testing transformer
   - Measurement of root-mean-square value and peak value
   - Measuring spark gap

4. Generation and measurement of impulse voltages
   - Impulse voltage cascade with respect to Marx
   - Impulse voltage measurement
   - Statistical analysis of measurement results

5. Travelling waves
   - Single and multiple reflections
   - Wave-pattern with respect to Bawley
   - Diverters
   - Isolation-co-ordination

- Non-destructive measurement of high voltage

High Voltage Engineering Laboratory

Term:	EE8
Semester periods per week:	2SWS
Type:	Laboratory
Verification	Laboratory experiments

Contents:

1. Determination of electrostatic fields on conductive paper
2. Computer-program for determination of electrostatic fields with the equivalent charge method
3. Demonstration of safety devices
4. Routine test of a disconnector with respect to VDE 0670 (German Standard)
5. Generation of cut lightning impulse voltage with respect to VDE 0433
6. Impulse voltage-time curve in inhomogeneous spark gap
7. Electromagnetic influence due to lightning impulse voltage
8. Measurement and calculation of travelling waves

Construction and Design

Term: EE4
Semester periods per week: 2SWS
Type: Laboratory
Verification Student Research Project

Contents (in parenthesis number of lessons):

1. Introduction to scientific work
   - Presentation techniques (2)
     - Recommendation for preparation of a speech or a presentation
     - Technical presentation, psychological basics of a technical presentation
     - Improvement of memorisation
     - Rhetoric
   - Report (1)
     - Fundamentals
     - Reports to 1st and 2nd practical term
     - Laboratory reports, final thesis
     - Norms for utilisation in publications
   - Explication for searching and finding of literature (1)
     - Fundamentals
     - Scientific libraries
     - Different types of bibliographies, explanation to searches
     - Recommendation for personal registration
2. Introduction to Standards (Norms)
   - Meaning of technical-scientific Standards (2)
     - Fundamentals
     - Technical Standards, Organisations of standardisation
     - Literature with introduction to Standards, Standards for drawings
   - Utilisation of VDI 2221 and VDI 2222 (1)
   - Engine- and Design-elements (Overview) (2)
     - Terms
     - Introduction to Engine- and Design-elements

     If time allows:
   - Function-orientated and economical design - some hints
     - Influence to the functionality and economy of designs
     - Load capability of designs
     - Appearance-orientated designs
     - Material-orientated designs

Educational Objective:

- Knowledge of fundamentals of presentation techniques
- Opportunity of exercise of presentations with hints for improvement of technique for each presenter individually
- Meaning of Standardisation and utilisation of the most important standards

Electrical Power Stations

Term:	EE7
Semester periods per week:	2SWS
Type:	Lecture
Verification	Written examination, 90min

Contents:

1. Sources of energy
   - Resources
   - Extended resources
   - Rational energy usage

2. Types of power plants
   - Fossil steam power plant, nuclear power plant, gas turbine power plant
   - Combined power plant, diesel power plant

3. Renewable energy resources
   - Hydro-electric power plant, wind power plant
   - Geothermal plants, solar power plants

4. Electrical components of power plants
   - Generators, transformers
   - Distribution system
   - Motors, Engines
   - Supplementary devices
   -

5. Control of power plants
   - Voltage control, frequency control
   - Voltage- and Frequency deviation

6. Protection equipment
   - Generator protection, transformer protection
   - Motor protection

7. Control and instrumentation technique
   - Fundamentals

Educational Objective:
- Understanding for rational utilisation of conventional and renewable energy resources
- Understanding for usage of different types of power plants
- Understanding for operation modes, parallel operation, control and protection of different types of power plants and equipment

Power electronics 1

Term:	EE5
Semester periods per week:	4SWS
Type:	Lecture
Verification	Written examination, 135min

Contents:

1. Introduction
   - External operation of electrical power converters
   - Internal operation of electrical power converters

2. Thyristors
   - Method of operation
   - Thermal behaviour
   - Dynamic behaviour
   - Types of thyrisors

3. Line-commutated converters
   - Two-, Three-, Six-, Twelve-pulse converters
   - Star connection, bridge connection
   - Series connection and interface transformer connection
   - Commutation
   - Current ratio on the side of alternating current, converter transformer
   - Alternating voltage on the side of direct current, smoothing reactor, intermittent flow
   - Low reactive power converters
   - Reversible-converter, double-way converter

The lecture is supplemented by exercises.

Power electronics 2

Term:	EE7
Semester periods per week:	2SWS
Type:	Lecture
Verification	Interdisciplinary written examination, "Converter-drives"

Contents:

1. Semiconductor switches (turn-on, turn-off)
   - MOSFET, IGBT, GTO, MCT
   - Switching operation
   - Driver circuit, short-circuit protection
   - Circuits

2. Chopper controller with load independent direct voltage
   - Step-down converter, step-up converter
   - Multi-quadrant chopper controller
   - Controlling with and without feedback-loop

3. Power inverter with load independent direct voltage
   - One-phase / three-phase
   - Pulse-control, harmonic spectrum
   - Three-step inverters

4. Inverters with load independent direct current

The lecture is supplemented by exercises.

Lightning Engineering

Term:	EE5
Semester periods per week:	2SWS
Type:	Lecture and project in groups
Verification	Project presentation

Contents (in parenthesis number of lessons):

1. Physical Fundamentals (4)
   - Terms
     Solid angle, luminous flux, illuminance, light-emitting diode (LED)
     Photometric law of distance
   - Light and substance
     Reflection, transmission, absorption
2. Fundamentals of lightning engineering (8)
   - Radiation and light
     Spectra, the eye
   - Light generation, lamps
     Evaluation of lamps
     Incandescent lamp / halogen lamp, discharge lamp, fluorescent lamp
     Operational equipment
   - Luminaire, lightning fitting
     Functions of lightning fittings
     Luminaire efficiency, luminous intensity distribution curve
   - Quality criterion of illumination
     Illuminance, DIN 5035
     Glare
3. Basics of daylight (2)
   - Utilisation of daylight
     Ratio of daylight
     Sun-protection
4. Project (in groups) (16)
   - Planning of a lightning system of a complex system (e.g. Bank, town hall) with respect to technical and economical and aspects.

Educational Objective:
- Solving of simple problems of light-technique
- Capability of working in interdisciplinary groups (Electrical-engineers and Civil-engineers)
- Capability of short and precise presentations

Mathematics 1

Term:	EE1
Semester periods per week:	8SWS
Type:	Lecture
Verification	Written examination, 135 min.

Contents (in parenthesis number of lessons):

1. Fundamentals (4)
   - Logic operations, methods of verification
   - Set theory, relations

2. Linear algebra (40)
   - Structures
   - Determinants
   - Vector-algebra, matrix-algebra
   - Equation-systems

3. Differential equations (50)
   - Real functions, inverse function
   - Series, sequence
   - Limiting value of series and functions
   - Derivations
   - Graph characterisation/discussion
     polynomial function
     rational function

4. Application of differential equations (6)
   - Linearisation
   - Mean value
   - Rules of de l'Hospital

5. Polynoms (10)
   - Horner scheme
   - Zero of polynoms
   - Interpolation-polynoms

The lecture is supplemented by exercises (10).

Educational Objective:
- Repetition of important fundamentals: determinants and differential equations
- Introduction to vector- and matrix-algebra with application to equation-systems
- Applications of differential equations and poly-arithmetic

Mathematics 2

Term:	EE2
Semester periods per week:	8SWS
Type:	Lecture
Verification	Written examination, 135 min.

Contents (in parenthesis number of lessons):

1. Complex numbers (10)
   - Introduction
   - Standard form and trigonometric form of complex numbers
   - Exponential form

2. Infinite series (10)
   - Explanation of infinite series
   - Potential functions, MaxLaurin-series, Taylor-series

3. Calculation of Integrals (30)
   - Definite integrals
   - Indefinite integrals
   - Methods for solutions
     - Substitution
     - Product-integral
     - Partial fraction
4. Application of Integrals (20)
   - no-real Integrals
   - Fourier-series
   - Laplace-integral

5. Differential equations (30)
   - Differential equations of 1st, 2nd and higher order
   - Solutions with Laplace-transformation

6. Functions with multiple variables (10)
   - Partial derivation
   - Regression-curve and polynoms

The lecture is supplemented with exercises (10).

Educational Objective:
- Introduction complex numbers and infinite series
- Application of integral methods with various exercises
- Solution of differential equations with usual methods and also with Laplace-transformation

Mathematics 3

Term:	EE4
Semester periods per week:	2SWS
Type:	Lecture (elective subject)
Verification	Project

Contents (in parenthesis number of lessons):

1. Repetition of integral methods (4)
   - Substitution
   - Product integration
   - Partial fractions

2. Fourier-series (2)

3. Laplace-transformation (10)
   - Separation of variables
   - Theorems and rules for Laplace-transformation
   - Inverse transformation

4. Differential equations (14)
   - Separation of variables
   - Variation of constants
   - Solution with Laplace-transformation
   - Systems of differential equations
   - Examples for applications

The lecture is supplemented with exercises.

Educational Objective:
- Repetition of integration methods, specially the partial fractions which is then necessary for the inverse Laplace-transformation
- Confidence in solving differential equations with Laplace-transformation
- Knowledge of most important examples of applications

Microcomputer Technology

Term:	EE5
Semester periods per week:	4SWS
Type:	Lecture
Verification	Written examination, 135 min

Contents (in parenthesis number of lessons):

1. Introduction
   - Historical overview
   - Processing and representation of data
2. Architecture of computer systems (8)
   - Microcontroller 80C535
   - Hierarchy of a CPU, CPU-timing
   - Memory-concept of 80©515/535
   - Special function register
   - Arithmetic of 8051-family
3. Software of 80C535 (4)
   - Functions of assembler and commands
   - Inputs of assembler, assembler-commands, different types of addressing and commands
4. Memory (2)
5. Input-Output-Ports (4)
   - I/O-Ports of 80C535
   - Programmable Input/Output-module
6. Time-generator/Counter (6)
   - Time-generator/Counter of 80C535
   - Programmable time-generator/counter-module
7. Analogue/Digital-converter
   - Analogue/Digital-converter-structures
   - Analogue/Digital-converter of 80C535
8. Interrupt-techniques in 80C51/535 (4)
9. Microcontroller-interfaces (8)
   - Serial transmission
   - Parallel transmission

The lecture is supplemented with exercises and software-simulation on PC.

Educational Objective:

- Knowledge of structures of Microcontroller-systems and functionality of Microcontrollers
- Experience in programming in assembler

Microcomputer Technology, Laboratory

Term:	EE7
Semester periods per week:	2SWS
Type:	Laboratory
Verification	Project

Contents:

Execution of projects in the field of Microcontroller-applications in groups of at most three students. The topic of the project could be defined by the students within a certain frame. Project-planning, purchase, programming, structure and test is the responsibility of the groups. Verification takes place in a presentation of the project.

Educational Objective:

- Exercise in execution of projects in the field of Microcontroller applications

Physics 1

Term:	EE1
Semester periods per week:	4SWS
Type:	Lecture
Verification	Written examination, 135 min

Contents (in parenthesis number of lessons):

1. Fundamentals of mechanics (4)
   - Three laws of Newton with examples
2. Forces (12)
   - Spring-forces
   - Forces on moving charge in electrical fields with examples
   - Forces on moving charge in magnetic fields with examples
   - Friction-forces
   - Gravitation-forces with examples
3. Work and energy (12)
   - Work with constant and variable forces
     Example: lift-, elongation-, acceleration- friction-work
   - Conservative forces and potential energy
   - Potential energy in central-symmetric gravitation-fields and electrical fields
   - Theorem of preservation of energy, examples
4. Dynamics of translatory movements (6)
   - Impulse of a system with mass-points
   - Theorem of preservation of impulse
   - Linear elastic and inelastic impact between masses, example
5. Dynamic rotationary movements (12)
   - Angular momentum and moment of momentum of a mass-point.
     Example of rotationary movement and the general plane movement
   - Preservation-law of angular momentum (example planet-movement, H-atom)
   - Angular momentum and moment of momentum of rigid objects
   - Momentum of inertia, theorem of Steiner
   - Theorem of preservation of angular momentum

The lecture is supplemented wth various exercises (10).

Educational Objective:

The student should
- get confidence with the various "instruments" of mechanics.
- get knowledge of fundamental laws of preservation in physics to use for solution-finding of problems in the field of mechanics and other fields of physics.

Physics 2

Term:	EE2
Semester periods per week:	2SWS
Type:	Lecture
Verification	Written examination, 135 min (inclusive Physics-2-Laboratory)

Contents (in parenthesis number of lessons):

1. Thermal status-values (2)
   - Temperature and measurement of temperature
   - Pressure and measurement of pressure
2. Ideal gas (3)
   - Equations of status
   - Isothermal, isobar and isochorous processes
   - Status-plane of ideal gas in the p-V-T-space
   - Status-plane of a pure element with all phases in p-V-T space
3. Caloric status-values (5)
   - Internal energy U, Entropy S, Enthalpy H
4. Process-values
   - Volume-expansion work, Heat-energy
   - 1st and 2nd Theorem of thermodynamics
5. Reversible thermodynamic processes, 1st theorem (7)
   - Isochorous process, isobar process, isothermal process, isentropic process
   - p-V and T-S-Diagrams
6. Circuit process (5)
   - Thermal efficiency
   - Special circuit processes (Carnot-process, Stirling-process, Ericson-process)
7. Exergy and Anergy
   - Formulation of 1st and 2nd Theorem of thermodynamics with the two terms Exergy and Anergy
   - Exergy- and Anergy-flowchart for the following thermodynamic processes: Heat-engine, compression-heat-pump, absorption-heat-pump, heat-transformer)
     electrical resistor-heating, heat-transfer through walls

The lecture is supplemented with various examples and exercises

Educational Objective:

- Confidence in fundamentals and way of thinking in thermodynamics
- Understanding of differences between reversible and irreversible processes
- Understanding why in circuit processes the heat never can be transformed in work
- Evaluation of "quality" of a thermodynamic process with Exergy and Anergy.

Physics 2 - Laboratory

Term:	EE2
Semester periods per week:	2SWS
Type:	Lecture
Verification	Written examination, 135 min (inclusive Physics-2-Laboratory)

Contents (in parenthesis number of lessons):

1. Introduction in error- and compensation-calculation
   - Statistical error-calculation (2)
     - Direct observation of equal accuracy
     - Mean-value, standard deviation, mean error, Gaussian distribution,
     - Student- or t-distribution
     - Direct observation of unequal accuracy
     - Summary of series of measurement of unequal accuracy, weighting-factor, overall mean value, mean error
     - Indirect observation
     - Error-propagation of random errors according to Gauss
   - Largest error calculation (2)
     - Estimation of largest error of a measurement
     - Derivation of largest error according to error-limits of measurement instruments
   - Linear regression - mean straight line (2)
     - Linear function
     - Non-linear function (exponential-, logarithmical-, potential-functions)
2. Laboratory-projects
   - Mechanics (10)
     - Guide values with different helical springs
     - Mass inertia of different rotationary objects
     - Physical pendulum
     - Damped oscillation
     - Constrained linear oscillation
   - Electrical engineering (6)
     - Series resonant circuit
     - e/m specification
     - Current weighter
   - Optics and atomic physics (6)
     - Focal distance of thin lenses
     - Spectral analysis with prismatic spectrometer
     - Franck-Hertz-experiment

Project Management

Term:	EE7
Semester periods per week:	2SWS
Type:	Lecture
Verification	Written examination, 90 min or homework with presentation

Contents:

1. Different types of company organisation
   - Structure
   - Functional sequence

2. Systematic of project management
   - Project and project management
   - Different types
   - Elements

3. Project management with emphasis on purchase
   - Functional specification
   - Example of a manual of a project manager

4. Project management with emphasis on development R&D
   - Functional specification
   - Example of a manual of a project manager

5. Information flows in companies

Process Automation

Term:	EE8
Semester periods per week:	4SWS
Type:	Lecture
Verification	Written examination, 135 min, or student research project or laboratory project

Contents (in parenthesis number of lessons):

1. Fundamentals of process automation (2)
   - Tasks and structure of automation systems
   - Mathematical fundamentals
2. Hardware in process automation (4)
   - Hardware of process computers
   - Binary and analogous inputs and outputs
3. Signal processing in sampled-data systems (10)
   - Structure of sampled-data systems
   - Digital signal processing / filter
4. Software in process automation (8)
   - Structure of software of process computers
   - Operating systems
   - Real-time programming languages
   - Application software / IEC 1131-3
5. Reliability and electromagnetic compatibility (8)
   - Reliability of automation systems
   - Electromagnetic compatibility
6. Bus systems in automation technique (12)
   - Structures of automation and networks of devices
   - Principles of communication
   - Field bus
7. Automation in switching stations (12)
   - Secondary technique in switching stations
   - Protection and control
   - Station control and instrumentation technology

Educational Objective:

- Overview of concepts, possibilities and frontiers of automation systems
- Knowledge of typical Hardware solutions, software, signal processing and communication
- Deepening of knowledge of solutions in automation in electrical energy supply

Law

Term: EE5
Semester periods per week: 2SWS
Type: Lecture with exercises
Verification Written examination, 90 min,

Contents:

1. Types of contracts
   - Contract of employment
   - Travel contract
   - Broker contract
   - Contract for work and labour and similar contracts

2. Conclude a contract
   - In place of, by deputy
   - Adultness
   - Declaration of will
   - Conditions
   - Right of co-determination
   - Permission

3. Contents of a contract
   - Impossible fulfilment
   - Negative interest
   - Determination of fulfilment of a party
   - avoidance clause
   - Appointment
   - Statutory period of limitation

4. Withdraw of a contract
   - Action of withdraw
   - Withdraw due to non-fulfilment

5. Claim of compensation

6. Law cases of some known verdicts

The lecture is supplemented with visit of a judicial hearing in the court of Konstanz "Landgericht Konstanz", followed by a discussion with the judges.

Control Engineering 1

Term: EE4
Semester periods per week: 4SWS
Type: Lecture with exercises
Verification Written examination, 135 min

Contents (in parenthesis number of lessons):

1. Tasks of control engineering (8)
   - Introduction with examples
     - Levelling control
     - Control with and without feedback loop
   - Terms and fundamental tasks of control engineering
     - Transmission systems
     - Principle of self-excitation, instability
     - Feasibility
     - Power gain
2. Classical linear controllers (4)
3. Classical non-linear controllers (2)
4. Principle of feedback-loop
   - One- and multiple-loop control loops
   - Cascade-control
   - Feed-forward control
5. Description with models of dynamic behaviour of real systems (12)
   - Similarities between electrical and mechanical networks
   - Transmission systems of first order
   - Transmission systems of second order
     - Standard form of state representation
     - Input and output representation
   - Structure image
   - Amplitude- and time normalisation
   - Linearity
   - Linearisation in the working point

6. Methods for solving differential equations (12)
   - Solution in the time range and with Laplace-transformation
   - Transfer function G(s)
   - Convolution integral
   - Calculation of system response with various excitation functions
   - Transfer systems of n-th order
   - Feasibility

The lecture is supplemented with detailed exercises (22)

Control Engineering 2

Term: EE5
Semester periods per week: 2SWS
Type: Lecture with exercises
Verification Written examination, 90 min

Contents (in parenthesis number of lessons):

1. Frequency response G(jw) (4)
   - Definition and physical understanding of frequency responses
   - Nyquist-circle-diagram of PT1-, PT2-, PTn- and lag element
   - Bode-diagram of elementary frequency response
   - Phase-minimum transfer-element
   - Filter: low-pass of 1st and 2nd order, high-pass, band-pass, all-pass network

2. Analysis of control loops (2)
   - Transfer functions of closed-loop control loops
     - Reference functions
     - Disturbance-functions
     - Closed-loop transfer function
   - Mason-rule
   - P-, I-, D-behaviour of L(s)
   - Steady state deviation

3. Stability of transfer systems (6)
   - BIBO-stability
   - Stability of transfer functions
   - Stability criteria
     - Hurwitz-Routh-criteria
   - Simplified Nyquist-criteria
     - Amplitude edge
     - Phase edge

4. Design of controllers with help of frequency-response characteristic (6)
   - P-controller
   - PI-controller
     - Phase-edge and optimum of absolute-value
     - Symmetrical optimum
   - PD-controller, real PD-controller
   - Correction-factor: Lag-Lead

The lecture is supplemented with detailed exercises (12)

Control Engineering Laboratory

Term: EE7
Semester periods per week: 2SWS
Type: Laboratory
Verification Student research project, laboratory project

Contents (in parenthesis number of lessons):

1. Description of static and dynamic behaviour of transfer systems (6)
   - Static characteristics
   - Transfer function
   - Frequency response

2. Simulation of transfer systems (4)

3. Optimisation of control loops with simulation programs (6)
   - Adjusting parameters according to Ziegler and Nichols
   - Optimal parameter adjusting according to square weighting criteria

4. Cascade control of converter-fed drive (10)
   - Optimisation of absolute-value of armature current controller
   - Symmetric optimum of speed controller

5. Temperature control with two-level control (4)

Educational Objective:
- Metrological seizing and analysis of tasks in control engineering
- Practical application with simulation programs
- Hardware (equipment) realisation and parameterisation of an industrial drive
- Experience with parameterisation of non-linear control loops.

Sensor Technology

Term: EE7
Semester periods per week: 2SWS
Type: Lecture
Verification Written examination, 90 min

Contents (in parenthesis number of lessons):

1. Application of Hall-effect (6)
   - Current-sensor, power-sensor, magnetoresistor, tachometer-generator brush-less direct current motor

2. Application of piezoelectrical effect (7)
   - Piezoelectrical material, force sensor, torque sensor, pressure sensor, acceleration sensor, charge amplifier, resonator, electromechanical and mechanic-electrical converters

3. Strain gauge (5)
   - Metallic strain gauge, semiconductor strain gauge, piezoresistance-effect, bridge circuit, temperature compensation, force sensor, pressure sensor, torque sensor

4. Application of thermal effects (10)
   - Seebeck-effect, thermocouple, resistance thermometer, NTC-thermistor, PTC-thermistor, silicon temperature sensor, silicon transistor as temperature
     sensor, radiation thermometer (Pyrometer)

5. Application of optical effects (4)
   - Internal photoeffect, photoresistor, photo-diode, solar cell, photo-transistor, luminescent diode, laser-diode, photoelectric barrier, speed sensor, optocoupler

6. Inductive and capacitive sensors (2)
   - Differential transformer, electrodynamic and electromagnetic oscillation sensor
     capacitive displacement sensor, differential sensor

7. Digital sensors (2)
   - Encoded angle- and length-sensor, incremental angle- and length-sensor

Educational Objective:
- Utilisation of physical effects for measurements of non-electrical values
- Selection of sensor-principle for special measurement-tasks
- Design of respective signal processing

SPS, Programmable Logic Controller

Term: EE5
Semester periods per week: 2SWS
Type: Laboratory
Verification Laboratory project with final presentation

Contents:

In project work typical tasks in programmable-logic-controllers (SPS) are discussed:
- Hardware- and Software commissioning of SPS with example programs
- SPS-software for control of process models (e.g. sorting systems)
- Comparison of different SPS-Systems and SPS-programming languages for solving of automation problems
- Programming of control units for automation in switching systems, e.g. automatic reclosing control equipment
- Project planning and commissioning of field-bus systems

Programming with Personal Computer with programming languages according to standard IEC 1131-3. Modern SPS-systems are available (e.g. Siemens S5 / S7, ABB control unit REC580). Focus of laboratory is the network of automation units with field-bus system Profibus.
The Laboratory project is for groups of two or three. Laboratory equipment and tasks are co-ordinated with the faculty MB (mechanical engineering)

Educational Objective:
- Knowledge of hardware-equipment and possibilities of programming and application of a SPS-system
- Project-orientated solution of tasks in the field of SPS-hardware, SPS-software, communication in automation systems, SPS-applications in electrical engineering
- Deepening of knowledge in SPS-programming language (e.g. sequential function chart SFC)

Technical Mechanics 1

Term:	EE1
Semester periods per week:	4SWS
Type:	Lecture
Verification	Written examination together with Technical Mechanics 2, 135 min

Contents (in parenthesis number of lessons):

1. Statistics (24)
   - Fundamentals and axioms of rigid objects
   - Plane force-system with common points of action
   - General plane force-system, centre of mass

2. Strength of materials (24)
   - Tension- and compressive stress
   - Bending-stress of straight bars
   - Torsion-stress of waves
   - Bending and folding

The lecture is supplemented with exercises (16).

Educational Objective:
- Capability to calculate in simple wing-units and known external forces the bar-and cable-forces
- Capability to calculate bars for tension-, compressive- and bending-stress and also waves for torsion-stress

Technical Mechanics 2

Term:	EE2
Semester periods per week:	2SWS
Type:	Lecture
Verification	Written examination together with Technical Mechanics 1, 135 min

Contents (in parenthesis number of lessons):

1. Kinematics of points (6)

2. Kinetics of mass points (8)

3. Torsion of rigid objects around fixed axles (10)

The lecture is supplemented with exercises (8).

Educational Objective:
- Capability to calculate movement of objects if geometric values, forces and angular momentum are known
- Knowledge of torsion- and natural-bending frequency of staggered shafts

Technical English

Term: EE1
Semester periods per week: 2SWS
Type: Lecture
Verification Written examination 90 min

Contents (in parenthesis number of lessons):

1. Reading matter, translation and discussion of technical English texts (8)

2. Conversation exercise in electrotechnical topics (8)

3. Written exercises in electrotechnical topics (4)

4. Comprehension exercise through technical video films (4)

5. Repetition of fundamental structures of the English language (6)

Educational Objective:
- Development of capability to read technical English texts
- Development of capability to discuss and write about technical topics
- Development of capability to understand English presentations and discussions

Theory of Alternating Current 1

Term:	EE2
Semester periods per week:	6SWS
Type:	Lecture
Verification	Written examination together with Electrical Metrology 1, 180 min

Contents (in parenthesis number of lessons):

1. Fundamentals (12)
   - Fundamental terms, behaviour of resistors, coils and capacitance under sinusoidal voltage

2. Calculation with complex pointers (58)
   - Alternating- and three-phase circuits, circle diagram
   - Oscillating circuit, filtering circuit

3. Fourier-extraction (8)

The lecture is supplemented with exercises (18)

Educational Objective:
- Capability to calculate alternating- and three-phase networks with complex pointers
- Knowledge of series- and parallel resonant circuit
- Design of simple filtering circuits
- Capability to separate periodic values according to Fourier.

Theory of Alternating Current 2

Term:	EE4
Semester periods per week:	2SWS
Type:	Lecture
Verification	Written examination 135 min

Contents (in parenthesis number of lessons):

1. Switching of R-C-circuits (6)

2. Switching of R-L-circuits (12)

3. Switching of R-L-C-circuits (6)

The lecture is supplemented with exercises (8)

Educational Objective:

- Knowledge of transient reactions and the inherit over-voltage and over-current and the possibility of limitation.
- Capability to calculate switching-operation with one or two energy storages.

Thermodynamics

Term: EE5
Semester periods per week: 2SWS
Type: Lecture
Verification Written examination 90 min

Contents (in parenthesis number of lessons):

1. Thermodynamic fundamentals (1)
   - Experience, terms
   - Different types of energy transmission
2. 1st and 2nd theorem of thermodynamics (4)
   - Systems without mass exchange
   - Systems with mass exchange
   - Enthalpy and Entropy
   - Thermal efficiency
3. Gases and gas-mixtures (2)
   - Real and ideal gases
   - Change of state of ideal gases
   - Mixed ideal gases
4. Multiple-phase systems (3)
   - State values in two-phase-region
   - State diagram in two-phase-region
5. Important circuit processes (3)
   - Otto-circuit process ("Hubkolbenmotor", lifting cylinder motor)
   - Clausius-Rankine-circuit process (steam power plant)
   - Foule-Brayton-circuit process (gas-turbine)
6. Incompressible fluid motion and heat-transfer (2)
   - Application of energy equation to fluid motions
   - Different types of heat-transfer (conduction, convection, radiation)
   - Heat-transmission

The lecture is supplemented with exercises

Educational Objective:
- Understanding of tasks of thermal mechanical engineering (pressure, temperature, heat, work, fluid-motion)
- Capability to solve simple thermal problems

Environmental Technology

Term:	EE8
Semester periods per week:	2SWS
Type:	Lecture
Verification	Written examination 90 min, or Project, Presentation

Contents:

1. Environment-orientated topics
   - CO2-redutcion
   - Utilisation of renewable energy
   - Solar energy

2. Attitude as basis for understanding of social behaviour
   - Agenda 21
   - Study "Germany with future" ("Zukunftsfaehiges Deutschland")

3. Internal environmental-treatment within companies

4. Quality management
   - Ecology-audit
   - ISO-system

5. Environmental economy

Remark:
The lecture is not hold in the classical style. At the beginning of the term the topics are discussed, while the interests of the students are the main focus.
With presentations and discussions and also project-work the knowledge and methodical capabilities are practised. Finally a minimum of three excursions take place.

Economics

Term: EE4
Semester periods per week: 2SWS
Type: Lecture
Verification Written examination 90 min or presentation

Contents:

1. Introduction
   - Development of economy, problems and methods

2. Supply and demand
   - Micro-economy
   - Household (budget, necessities and profit, demand)
   - Enterprise (production, costs and proceeds, supply)
3. Economical circuits
   - Macro-economy
   - Goods- and money-circulation, economical calculations, cash-balance
   - GDP : Gross Domestic Product and social income, money-volume
4. Economic policy
   - Economic policy aims and instruments
   - Economic growth, price-stability, full employment, foreign trade equilibrium
5. National finances
   - Tasks and national expenditure
   - Tax and payments
6. Example in economics
   - Simulation model for two political economics
   - Aim and decisions, markets, foreign affairs, coherence
7. Growth and environment
   - Growth of economy, limits of growth, environmental problems
   - Aims and strategies, environment politics

Educational Objective:
- Knowledge of fundamentals of economics
- Analysis of singular economical decisions
- Fundamentals of production theory
- Understanding of supply- and demand-ratio of household and enterprises
- How does a market-mechanism work? Which tasks and meaning have prices?
- Goods- and money-circuits
- How does the economy-circuit work in economics?
- Discussion on economic-political aims and instruments
- Which relations exist between economy and environment?

Materials Science

Term: EE2
Semester periods per week: 4SWS
Type: Lecture
Verification Written examination 135 min

Contents (in parenthesis number of lessons):

1. Structure of substance (22)
   - Elementary particle, atom-model, periodic system of elements, different types of binding-connections, aggregate state, gases, fluids, amorphous rigid objects, crystals, crystal-error, thermal equilibrium, diffusion
2. Properties of rigid objects (5)
   - Mechanical properties, electrical properties, field current, diffusion current,
3. Metals (6)
   - Electrical resistance, temperature coefficient of resistors, supra-conductivity, Alloy-diagrams, iron-carbon-diagram
4. Semiconductors (6)
   - Intrinsic semiconductor, extrinsic semiconductor, temperature dependency of conductivity
5. Magnetic materials (6)
   - Magnetic field values, diamagnetism, paramagnetism, ferromagnetism, anti-ferromagnetism, ferrimagnetism, hysteresis curve, loss code number, magnetically soft and hard application
6. Dielectric materials (8)
   - Electrical field values, polarisation mechanism, dielectric constant, electrical conductivity, loss factor, electrical disruptive discharge, piezo-electricity, Ferro-electricity, organic dielectric, insulating ceramic, crystals

Exercises (3)

Educational Objective:
- Knowledge of physical process inside of materials
- Understanding between physical processes inside of materials and the external material characteristics
- Judgement of materials according to the application and its possibilities of influence.