M.Sc. Electrical Engineering and Information Technology (PO 2014)

Sensors, Actuators and Electronics
Date: 01.10.2020

TECHNISCHE UNIVERSITÄT DARMSTADT

Department of Electrical Engineering and Information Technology

Module manual: M.Sc. Electrical Engineering and Information Technology (PO 2014)
Sensors, Actuators and Electronics
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Department of Electrical Engineering and Information Technology
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Contents

1 Fundamentals

Module name Advanced Digital Integrated Circuit Design					
Module Nr. 18-ho-2010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** MOS Transistor Models, CMOS Logic Gates, Chip Layout and Design Rules, Static and Dynamic Behavior of CMOS Circuits, Synchonous CMOS Circuits, Performance and Power Characterisation, Design Techniques and CAD Tools, FPGA and Gate Array Technologies, Memory Technologies, Chip Test.
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to • understand the short-channel effects of modern CMOS transistors, • derive and analyse the most important circuit concepts for digital logic gates, • understand the design flow of digital ASICs based on standard cells (design, layout, simulation/verification), • knows the pros and cons of synchronous vs. asynchronous logic, multiclockphase systems, • understands the differential design methods of integrated circuits (ASIC, ASIP, Full-custom/Semicustom, PLA, PLD, FPGA), • understands basic circuitry of logic and arithmetic units (adders, multipliers, PLL/DLL), • knows the design principles and properties of integrated semiconductor memory (DRAM, SRAM, Flash. MRAM, FeRAM)
3	**Recommended prerequisite for participation** Lecture “Electronics”
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture Slide Copies; John P. Uyemura: Fundamentals of MOS Digital Integrated Circuits; Neil Weste et al.: Principles of CMOS VLSI Design
Courses	

	Course Nr. 18-ho-2010-vl	**Course name** Advanced Digital Integrated Circuit Design		
	Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Lecture	**SWS** 3
	Course Nr. 18-ho-2010-ue	**Course name** Advanced Digital Integrated Circuit Design		
	Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Practice	**SWS** 1

Module name Microsystem Technology					
Module Nr. 18-bu-2010	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Ph.D. Thomas Peter Burg		

1	**Content** Introduction and definitions to micro system technology; definitions, basic aspects of materials in micro system technology, basic principles of micro fabrication technologies, functional elements of microsystems, micro actuators, micro fluidic systems, micro sensors, integrated sensor-actuator systems, trends, economic aspects.
2	**Learning objectives / Learning Outcomes** To explain the structure, function and fabrication processes of microsystems, including micro sensors, micro actuators, micro fluidic and micro-optic components, to explain fundamentals of material properties, to calculate simple microsystems.
3	**Recommended prerequisite for participation** BSc
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc WI-ETiT, MSc Medizintechnik
7	**Grade bonus compliant to §25 (2)**
8	**References** Script for lecture: Mikrosystemtechnik

Courses

Course Nr. 18-bu-2010-vl	**Course name** Microsystem Technology	
Instructor Prof. Ph.D. Thomas Peter Burg, M.Sc. Daniel Thiem	**Type** Lecture	**SWS** 2

Course Nr. 18-bu-2010-ue	**Course name** Microsystem Technology	
Instructor Prof. Ph.D. Thomas Peter Burg, M.Sc. Daniel Thiem	**Type** Practice	**SWS** 1

Module name Sensor Technique					
Module Nr. 18-kn-2120	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content**
2	**Learning objectives / Learning Outcomes** The Students acquire knowledge of the different measuring methods and their advantages and disadvantages. They can understand error in data sheets and descriptions interpret in relation to the application and are thus able to select a suitable sensor for applications in electronics and information, as well process technology and to apply them correctly.
3	**Recommended prerequisite for participation** Measuring Technique
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc WI-ETiT, MSc MEC, MSc Medizintechnik
7	**Grade bonus compliant to §25 (2)**
8	**References** • Slide set of lecture • Script of lecture • Textbook Tränkler „Sensortechnik“, Springer • Exercise script

Courses

	Course Nr. 18-kn-2120-vl	**Course name** Sensor Technique		
	Instructor Prof. Dr. Mario Kupnik		**Type** Lecture	**SWS** 2
	Course Nr. 18-kn-2120-ue	**Course name** Sensor Technique		
	Instructor Prof. Dr. Mario Kupnik		**Type** Practice	**SWS** 1

Module name Solid State Lighting					
Module Nr. 18-kh-2060	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Khanh Quoc Tran		

1	**Content** Basics of light and colour perception; basics of solid state light sources; LEDs: material systems, structural shape, optics, phosphors; phosphor mixtures; colour and white LEDs; temperature, current and optical behaviour of LEDs; LED models; lifetime and defect mechanisms of LEDs; OLEDs and semiconductor lasers in lighting engineering; optical sensors; semiconductor based cameras; colour sensors; colour quality of solid state light sources; choice and combination of LEDs in practical LED luminaires; flicker; grouping (binning) of LEDs according to their technological parameters; lighting quality metrics; intelligent indoor lighting with LEDs: colour recognition, spectral reconstruction; intelligent automotive and outdoor lighting with LEDs; practical training: thermic, electric and lighting engineering related measurement of LED light sources.
2	**Learning objectives / Learning Outcomes** Principles and applications of the technology of solid state light sources in lighting engineering; LED technology and the optimisation of visual perception under LED light in modern lighting engineering.
3	**Recommended prerequisite for participation** Lichttechnik I, II
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc etit
7	**Grade bonus compliant to §25 (2)**
8	**References** LED-Lighting: Technology and Perception (Khanh, Bodrogi, Vinh, Winkler; Editors,Wiley-VCH,2015) Introduction to Solid State Lighting (Zukauskas et al., Wiley, 2002) Light Emitting Diodes (Schubert; Cambridge Univ. Press, 2003)

Courses

Course Nr.	**Course name**		
18-kh-2060-vl	Solid State Lighting		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Khanh Quoc Tran, M.Sc. Alexander Georg Herzog		Lecture	2
Course Nr.	**Course name**		
18-kh-2060-pr			
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Khanh Quoc Tran, M.Sc. Alexander Georg Herzog		Internship	2

2 Optional Modules

2.1 SAE I: Extended Fundamentals

Module name Sensor Signal Processing						
Module Nr. 18-kn-2130	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe	
Language German			**Module owner** Prof. Dr. Mario Kupnik			
1	**Content** The module provides knowledge in-depth about the measuring and processing of sensor signals. In the area of primary electronics, some particular characteristics such as errors, noise and intrinsic compensation of bridges and amplifier circuits (carrier frequency amplifiers, chopper amplifiers, Low-drift amplifiers) in terms of error and energy aspects are discussed. Within the scope of the secondary electronic, the classical and optimal filter circuits, modern AD conversion principles and the issues of redundancy and error compensation will be discussed.					
2	**Learning objectives / Learning Outcomes** The Students acquire advanced knowledge on the structure of modern sensors and sensor proximity signal processing. They are able to select appropriate basic structure of modern primary and secondary electronics and to consider the error characteristics and other application requirements.					
3	**Recommended prerequisite for participation** Measuring Technique, Sensor Technique, Electronic, Digital Signal Processing					
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)					
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)					
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc MEC					
7	**Grade bonus compliant to §25 (2)**					
8	**References** • Slide set of lecture • Skript of lecture • Textbook Tränkler „Sensortechnik“, Springer • Textbook Tietze/Schenk „Halbleiterschaltungstechnik“, Springer					
Courses						
	Course Nr. 18-kn-2130-vl	**Course name** Sensor Signal Processing				
	Instructor Prof. Dr. Mario Kupnik			**Type** Lecture	**SWS** 2	

Module name Optical Communications 1 – Components					
Module Nr. 18-ku-1060	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr. rer. nat. Thomas Kusserow		

1	**Content** Optical telecommunication and data networks Optical transmisison systems The nature of light / wave-partical dualism Wave equation / planar wave Polarization Absorption, transmission, reflexion, refraction Connectors and splices Mirrors, HR-/AR coatings Film waveguides Fiber-optic waveguides Attenuation, modes, dispersion Fiber types Dispersion and dispersion compensation Kerr nonlinearity and self-phase modulation Optical filters Wavelength division multiplexers Magneto-optical effect / optical isolator / circulator Lasers / basics, concepts, types Erbium-doped fiber lasers / amplifiers (EDFL / EDFA) Optical semiconductor laser / amplifier (laser diode) Electro-optic modulator Other selected components and devices
2	**Learning objectives / Learning Outcomes** Students understand concepts, basics of physics, design criteria and system requirements (component specifications) of the most important passive and active components of optical communications.
3	**Recommended prerequisite for participation** ET 1-4, Physics
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, MSc ETiT, MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture slides Textbook (M. Cvijetic, I. B. Djordjevic: „Advanced Optical Communication Systems and Networks“)
Courses	

	Course Nr. 18-ku-1060-vl	**Course name** Optical Communications 1 – Components		
	Instructor Prof. Dr. rer. nat. Sascha Preu		**Type** Lecture	**SWS** 3
	Course Nr. 18-ku-1060-ue	**Course name** Optical Communications 1 – Components		
	Instructor Prof. Dr. rer. nat. Sascha Preu		**Type** Practice	**SWS** 1

Module name Identification of Dynamic Systems					
Module Nr. 18-ko-2040	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Ulrich Konigorski		

1 Content

- Introduction into the determination of mathematical process models based on measured data
- Theoretical and experimental modeling of dynamic systems
- System identification using continuous time signals:
  - Aperiodic signals
    - Fourier analysis
    - Evaluation of characteristic values (stepresponses)
  - Periodic signals
    - Frequency response analysis
    - Correlation analysis
- System identification using discrete time signals:
  - Deterministic and stochastic signals
  - Basics in estimation theory
  - Correlation analysis
- Parameter estimation techniques:
  - Least-squares estimation
  - Model structure determination
  - Recursive estimation algorithms
- Kalman Filter and Extended Kalman Filter
- Numerical Methods
- Implementation under MatLab Numerous examples with real experimental data

2 Learning objectives / Learning Outcomes

The students are taught the fundamental methods in signal and system analysis. Furthermore, the students master methods such as Fourier analysis, correlation analysis and parameter estimation methods. Based on this foundation, the students are able to assess and to apply the individual methods and can derive non-parametric as well as parametric models from measured data.

3 Recommended prerequisite for participation

MSc ETiT, MSc MEC

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

All disciplines of Electrical Engineering and Information Technology and similar disciplines (Mechatronics, Mechanical and Process Engineering, . . .), Master of Science

7 Grade bonus compliant to §25 (2)

8 References

	Pintelon, R.; Schoukens, J.: System Identification: A Frequency Domain Approach. IEEE Press, New York, 2001. Ljung, L.: System Identification: Theory for the user. Prentice Hall information and systems sciences series. Prentice Hall PTR, Upper Saddle River NJ, 2. edition, 1999.

Courses

	Course Nr. 18-ko-2040-vl	**Course name** Identification of Dynamic Systems		
	Instructor Dr. Ing. Eric Lenz, M.Sc. Jonathan Hermann		**Type** Lecture	**SWS** 2
	Course Nr. 18-ko-2040-ue	**Course name** Identification of Dynamic Systems		
	Instructor Dr. Ing. Eric Lenz, M.Sc. Jonathan Hermann		**Type** Practice	**SWS** 1

Module name Technical Mechanics for Electrical Engineering					
Module Nr. 16-26-6400	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 105 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr.-Ing. Tobias Melz		

1 Content

Statics: force, moment (torque), free body diagram, equilibrium equations, center of gravity, truss, beams, adhesion and friction.
Mechanics of elastic bodies: stress and deformation, tension, torsion, bending.
Kinematics: point and rigid body movement.
Kinetics: dynamic force and moment equilibrium equations, energy and work, linear oscillators, momentum and angular momentum conservation laws, impact.

2 Learning objectives / Learning Outcomes

In this course the students will learn the basic concepts of technical mechanics. They should be able to analyze the statics of simple statically determinate planar systems, to carry out elementary elastomechanical calculations of statically determinate and statically indeterminate structures, to describe and analyze movements, and to solve planar motion problems, oscillation and shock phenomena with the laws of kinetics.

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

7 Grade bonus compliant to §25 (2)

8 References

Markert, Norrick: Einführung in die Technische Mechanik, ISBN 978-3-8440-3228-4
Exercises are embodied in the book.
Further reading:
Markert: Statik – Aufgaben, Übungs- und Prüfungsaufgaben mit Lösungen, ISBN 978-3-8440-3279-6
Markert: Elastomechanik – Aufgaben, Übungs- und Prüfungsaufgaben mit Lösungen, ISBN 978-3-8440-3280-2
Markert: Dynamik – Aufgaben, Übungs- und Prüfungsaufgaben mit Lösungen, ISBN 978-3-8440-2200-1
Gross, Hauger, Schröder, Wall: Technische Mechanik 1 - 3. Springer-Verlag Berlin (2012-2014).
Hagedorn: Technische Mechanik, Band 1 - 3. Verlag Harri Deutsch Frankfurt.

Courses

Course Nr. 16-26-6400-vl	**Course name** Technical Mechanics for Electrical Engineering		
Instructor		**Type** Lecture	**SWS** 3

	Course Nr.	Course name		
	16-26-6400-ue	Technical Mechanics for Electrical Engineering		
	Instructor		**Type**	**SWS**
			Practice	2

Module name Electrical Machines and Drives					
Module Nr. 18-bi-1020	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. techn. Dr.h.c. Andreas Binder		

1 Content

Construction and function of induction machine, synchronous machine, direct current machine. Electromagnetic field within machines, armature windings, steady-state performance as motor/generator, application as line-fed and inverter-fed drives. Significance for electric power generation, both to the grid and in stand-alone version.

2 Learning objectives / Learning Outcomes

With active collaboration during lectures by asking questions related to those parts, which have not been completely understood by you, as well as by independent solving of examples ahead of the tutorial (not as late as during preparation for examination) you should be able to:

- calculate and explain the stationary operation performance of the three basic types of electric machine sin motor and generator mode,
- understand the application of electrical machines in modern drive systems and to design simple drive applications by yourself,
- understand and explain the function and physical background of the components of electrical machines
- understand and explain the impact of basic electromagnetic field and force theory on the basic function of electrical machines.

3 Recommended prerequisite for participation

Mathematics I to III, Electrical Engineering I and II, Physics, Mechanical Engineering

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

BSc ETiT, BSc/MSc Wi-ETiT, BEd

7 Grade bonus compliant to §25 (2)

8 References

Detailed textbook and collection of exercices; Complete set of PowerPoint presentations

L.Matsch: Electromagnetic and electromechanical machines, Int.Textbook, 1972
A.Fitzgerald et al: Electric machinery, McGraw-Hill, 1971
S.Nasar et al: Electromechanics and electric machines, Wiley&Sons, 1995
R.Fischer: Elektrische Maschinen, C.Hanser-Verlag, 2004

Courses

Course Nr. 18-bi-1020-vl	**Course name** Electrical Machines and Drives	
Instructor Prof. Dr. techn. Dr.h.c. Andreas Binder	**Type** Lecture	**SWS** 2

	Course Nr.	Course name		
	18-bi-1020-ue	Electrical Machines and Drives		
	Instructor		**Type**	**SWS**
	Prof. Dr. techn. Dr.h.c. Andreas Binder		Practice	2

Module name Technical Thermodynamics I					
Module Nr. 16-14-5010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 105 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Peter Christian Stephan		

1 Content

Fundamental terms of thermodynamics; thermodynamic equilibrium and temperature; different forms of energy (internal energy, heat, work, enthalpy); properties and equations of state for gases and incompressible substances; first law of thermodynamics and energy balances for technical systems; second law of thermodynamics and entropy balances for technical systems; exergy analysis; thermodynamic behaviour during phase change; the carnot cycle for power generation or refrigeration; energy efficiency and coefficient of performance; cyclic processes for gas turbines, combustion engines, power plants, refrigerators and heat pumps.

2 Learning objectives / Learning Outcomes

On successful completion of this module, students should be able to:

- Explain the relationships between thermodynamic properties and the thermodynamic state of a system and apply them within calculations of thermal system behaviour.
- Distinguish between different types of energy (e.g. work, heat, internal energy, enthalpy) and define them.
- Analyse technical systems and processes using energy balances and equations of state.
- Assess energy conversion processes by means of an entropy balance or an exergy analysis.
- Characterise the thermal behaviour of gases, liquids and solids and corresponding phase change processes.
- Apply this basic knowledge (1.-5.) to examine machines (turbines, pumps etc.) and processes for energy conversion (combustion engine, power plants, refrigerators, heat pumps).

3 Recommended prerequisite for participation

None

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Technical Examination, Standard Grading System)

Written exam 150 min

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Technical Examination, Weighting: 100 %)

6 Usability of this module

Bachelor MPE Pflicht
Bachelor WI-MB
Master ETiT MFT, Bachelor Mechatronik

7 Grade bonus compliant to §25 (2)

8 References

P. Stephan; K. Schaber; K. Stephan; F. Mayinger: Thermodynamik, Band 1: Einstoffsysteme, Springer Verlag.
Further material (slides, collection of exercises, table of fomulas etc.) is available through the Moodle system of TU Darmstadt.

Courses

	Course Nr. 16-14-5010-vl	**Course name** Technical Thermodynamics I		
	Instructor		**Type** Lecture	**SWS** 3
	Course Nr. 16-14-5010-hü	**Course name** Technical Thermodynamics I		
	Instructor		**Type** Lecture Hall Practice	**SWS** 1
	Course Nr. 16-14-5010-gü	**Course name** Technical Thermodynamics I - Group Exercise		
	Instructor		**Type** Group Practice	**SWS** 1

2.2 SAE II: Lectures

Module name Sensor Signal Processing					
Module Nr. 18-kn-2130	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content** The module provides knowledge in-depth about the measuring and processing of sensor signals. In the area of primary electronics, some particular characteristics such as errors, noise and intrinsic compensation of bridges and amplifier circuits (carrier frequency amplifiers, chopper amplifiers, Low-drift amplifiers) in terms of error and energy aspects are discussed. Within the scope of the secondary electronic, the classical and optimal filter circuits, modern AD conversion principles and the issues of redundancy and error compensation will be discussed.
2	**Learning objectives / Learning Outcomes** The Students acquire advanced knowledge on the structure of modern sensors and sensor proximity signal processing. They are able to select appropriate basic structure of modern primary and secondary electronics and to consider the error characteristics and other application requirements.
3	**Recommended prerequisite for participation** Measuring Technique, Sensor Technique, Electronic, Digital Signal Processing
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** • Slide set of lecture • Skript of lecture • Textbook Tränkler „Sensortechnik“, Springer • Textbook Tietze/Schenk „Halbleiterschaltungstechnik“, Springer

Courses

Course Nr. 18-kn-2130-vl	**Course name** Sensor Signal Processing	
Instructor Prof. Dr. Mario Kupnik	**Type** Lecture	**SWS** 2

Module name Advanced Lighting Technology					
Module Nr. 18-kh-2020	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Khanh Quoc Tran		

1	**Content** Chosen topics in lighting technology – current developments and applications: Street lighting, Physiology: Detektion / Glare / Lighing and Health, LED – Generation of white Light / State of the Art, Modern Methods of Light Measurement, Interiour Lighting, Display Technologies, Non-visual Light Impacts,UV-Applications, Automotive Lighting, Solar Modules.
2	**Learning objectives / Learning Outcomes** To know current developments and applications, list and connect terms, to illustrate special topics of lighting, measuring methods and application. Beeing able to measure base items in lighting technology, applying knowlegde of lighting and dedicated applications and further to enhance them with experiments. Developing a better understanding for light, color, perception and lighting situations.
3	**Recommended prerequisite for participation** Lighting Technology I
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Excercisebook: laboratory: lighting technology II

Courses

	Course Nr. 18-kh-2020-vl	**Course name** Advanced Lighting Technology		
	Instructor Prof. Dr.-Ing. Khanh Quoc Tran		**Type** Lecture	**SWS** 2
	Course Nr. 18-kh-2020-pr	**Course name** Advanced Lighting Technology		
	Instructor Prof. Dr.-Ing. Khanh Quoc Tran		**Type** Internship	**SWS** 2

Module name Optical Technologies in Car Lighting					
Module Nr. 18-kh-2041	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Khanh Quoc Tran		

1	**Content** History and standardisation of car lithing. Description of the oused lighting sources and the function of these(lowbeam, highbeam, bending light, stop lamp, daytime running light...), visuell perception, glare, detection, traffic infrastructure, traffic elements, interior lighting, driver assistance systems(GPS, Radar, Lidar...), methods of psychophysics, lighting application concepts in future automated vehicles. Voluntary trip planed to an automobile manufacturer
2	**Learning objectives / Learning Outcomes** To describe the basics and deepening knowledge of car lighting, understanding of the light distribution of head and rear lamps, to learn the basics of standardisation, enlarge glare and detection skills, know the traffic elements, as well as the driver assistance systems
3	**Recommended prerequisite for participation** Lighting technology 1(desireable)
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc WI-ETiT, MSc iST, MSc MEC, MSc MPE, MSc Physik
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture slides, Automotive Lighting and Human Vision, Handbuch Fahrassistenzsysteme

Courses

	Course Nr. 18-kh-2041-vl	**Course name** Optical Technologies in Car Lighting		
	Instructor Prof. Dr.-Ing. Khanh Quoc Tran		**Type** Lecture	**SWS** 2
	Course Nr. 18-kh-2041-pr	**Course name**		
	Instructor Prof. Dr.-Ing. Khanh Quoc Tran		**Type** Internship	**SWS** 1

Module name Computer Aided Design for SoCs					
Module Nr. 18-ho-2200	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** CAD-Concepts for the design and simulation of integrated system-on-chips
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to understand • The most important design and verification abstractions as well as the design flow for the design of integrated electronic systems, • Selected algorithms for optimization, simulation and solving of design tasks, • Advanced methods for the design and simulation of analog integrated circuits in modern CMOS technologies, • Advanced concepts of hardware description languages and their concepts (Verilog, VHDL, Verilog-A, Verilog-AMS, System-Verilog)
3	**Recommended prerequisite for participation** Lecture "Advanced Digital Integrated Circuit Design" (can be attended in parallel) and „Analog Integrated Circuit Design" and "Logic Design"
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iST, MSc MEC, MSc Wi-ETiT, MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References** Slide Copies

Courses

Course Nr. 18-ho-2200-vl	**Course name** Computer Aided Design for SoCs		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Lecture	**SWS** 2
Course Nr. 18-ho-2200-ue	**Course name** Computer Aided Design for SoCs		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Practice	**SWS** 1
Course Nr. 18-ho-2200-pr	**Course name** Computer Aided Design for SoCs		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Internship	**SWS** 1

Module name					
Computer Systems II					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-hb-2030	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Christian Hochberger		

1 Content

- Configurable Technologies
- FPGA architectures and properties
- System-On-Chip, HW components, SW toolchain, support SW
- Coarse grained reconfigurable architectures, PE architecture, Modulo schedu-ling

2 Learning objectives / Learning Outcomes

After completion of the module, students know reconfigurable technologies as well as chip architecture that employ them (e.g. FPGAs and CGRAs). They can select an ap-propriate technology for a given specific application. They know the components a system-on-chip (SoC) consists of. Students can configure and program an application specific SoC. They can map simple applications to a CGRA and know the limitations and pitfalls of this mapping.

3 Recommended prerequisite for participation

Thorough basic knowledge of digital circuits and computer achitecture. as can be ob-tained in the lectures “Logischer Entwurf” and “Rechnersysteme I”. Additionally, stu-dents should be able to write simple programs in the programming language C.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iST, MSc iCE, MSc Wi-ETiT

7 Grade bonus compliant to §25 (2)

8 References

The slides (in German) of the lecture can be obtained through moodle.

Courses

Course Nr.	Course name		
18-hb-2030-vl	Computer Systems II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger, M.Sc. Johanna Rohde		Lecture	3
Course Nr.	**Course name**		
18-hb-2030-ue	Computer Systems II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger, M.Sc. Johanna Rohde		Practice	1

Module name					
Digital Signal Processing					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-zo-2060	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Abdelhak Zoubir		

1	**Content** 1) Discrete-Time Signals and Linear Systems – Sampling and Reconstruction of Analog Signals 2) Digital Filter Design – Filter Design Principles; Linear Phase Filters; Finite Impulse Response Filters; Infinite Impulse Response Filters; Implementations 3) Digital Spectral Analysis - Random Signals; Nonparametric Methods for Spectrum Estimation; Parametric Spectrum Estimation; Applications; 4) Kalman Filter
2	**Learning objectives / Learning Outcomes** Students will understand basic concepts of signal processing and analysis in time and frequency of deterministic and stochastic signals. They will have first experience with the standard software tool MATLAB.
3	**Recommended prerequisite for participation** Deterministic signals and systems theory
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, Wi-ETiT, MSc Medizintechnik
7	**Grade bonus compliant to §25 (2)**
8	**References** Course manuscript Additional References: • A. Oppenheim, W. Schafer: Discrete-time Signal Processing, 2nd ed. • J.F. Böhme: Stochastische Signale, Teubner Studienbücher, 1998

Courses

Course Nr. 18-zo-2060-vl	**Course name** Digital Signal Processing		
Instructor Prof. Dr.-Ing. Abdelhak Zoubir, M.Sc. Di Jin, M.Sc. Martin Gölz		**Type** Lecture	**SWS** 3
Course Nr. 18-zo-2060-ue	**Course name** Digital Signal Processing		
Instructor Prof. Dr.-Ing. Abdelhak Zoubir, M.Sc. Di Jin, M.Sc. Martin Gölz		**Type** Practice	**SWS** 1

Module name Printed Electronics					
Module Nr. 16-17-5110	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Edgar Dörsam		

1	**Content** Printing technologies for functional printing (printing methods and systems); Design and materials for printed electronics (aerial, OFET, RFID); Activities for quality assurance; Examples of application (aerial, RFID, OFET, photovoltaic, batteries, lab on a chip).
2	**Learning objectives / Learning Outcomes** On successful completion of this module, students should be able to: • Describe the printing technologies that are applicable for "Printed Electronics". • Name materials that are appropriate to printing processes and to describe the impact of the materials on the design e.g. of antennas and OFETs. • Classify and rate different activites for quality assurance. • Explain basic functions, configurations, materials, and specific properties of printed antennas, RFIDs, photovoltaics and batteries. • Describe "Printed Electronics" as a multidisciplinary task that consists of electrical engineering, material science, and mechanical engineering.
3	**Recommended prerequisite for participation** Mechanical components and Mechatronics I and II recommended
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Technical Examination, Standard Grading System) Oral exam 30 min
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Technical Examination, Weighting: 100 %)
6	**Usability of this module** WPB Master MPE III (Wahlfächer aus Natur- und Ingenieurwissenschaft) WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik) Master ETiT IMNT; Master Mechatronik
7	**Grade bonus compliant to §25 (2)**
8	**References** The current lecture notes can be downloaded from the web pages of the institute while the semester is in session.

Courses

Course Nr. 16-17-5110-vl	**Course name** Printed Electronics	
Instructor	**Type** Lecture	**SWS** 2

Module name Digital Printing					
Module Nr. 16-17-5030	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. Edgar Dörsam		

1 Content

Terminology of digital printing; Workflow, screening, raster technology; Tonal value; Technology of digital printing (electrophotography, inkjet, thermal transfer printing); Toner, ink and print substrate; Design.

2 Learning objectives / Learning Outcomes

On successful completion of this module, students should be able to:

- Explain terms and the classification system of digital printing technology.
- Estimate the fields of application (of digital printing technologies).
- Describe the different principles of workflows.
- Describe the meaning of the term screening and the reproduction of halftones.
- Precisely explain the principles and technical details of electrophotography, thermal transfer printing, and inkjet printing.
- Give a general overview of different construction principles of digital printing systems.
- Rate environmental properties of digital printing systems.

3 Recommended prerequisite for participation

None

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Technical Examination, Standard Grading System)

Oral exam 30 min

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Technical Examination, Weighting: 100 %)

6 Usability of this module

WPB Master MPE III (Wahlfächer aus Natur- und Ingenieurwissenschaft)
WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)
Master ETiT INMT

7 Grade bonus compliant to §25 (2)

8 References

The current lecture notes can be downloaded from the web pages of the institute while the semester is in session.

Courses

Course Nr.	**Course name**		
16-17-5030-vl	Digital Printing		
Instructor		**Type** Lecture	**SWS** 2

Module name Machine Learning & Energy					
Module Nr. 18-st-2020	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1 Content

The analysis and interpretation of data becomes ever more important, also for engineers. Digitalization and Smart Grids are terms to describe a host of novel data-based services in the field of generation, distribution, consumption and marketing of (renewable) energy. The lecture presents the recent developments and their underlying principles of machine learning technology.

For a start we will describe the different problem settings of machine learning in a structured way (classification, regression, clustering, dimensionality reductions, time series models, ...) and present for each setting relevant applications from the energy sector (prediction of renewable energy or consumption in multimodal energy systems, fault detection and prediction, data visualization, robust investments decisions, customer analysis, probabilistic load flow, ...).

Thereafter we will briefly review necessary tools from optimization and probability theory, as well as introduce probabilistic graphical models. With these tools we will then study for each problem setting one or more machine learning algorithms in detail, together with use cases from the energy domain. Classic algorithms will be developed (e.g. linear regression, k-means, principal component analysis, ...) as well as modern ones (e.g. SVMs, Deep Learning, Collaborative filtering, ...). Practical exercise with Matlab will deepen the understanding and support student's active knowledge.

2 Learning objectives / Learning Outcomes

Students understand important machine learning problem settings and some key algorithms for each task. They know common applications thereof in the energy domain. Moreover, the students are able to apply and adapt those methods independently to new applications (not only from the energy domain).

3 Recommended prerequisite for participation

- Good knowledge of linear algebra and the foundations of numerical optimization (e.g. from the course 18-st-2010 Energieanagement & Optimierung)
- Using Matlab for programming the practical examples should pose no difficulty. A block tutorial on the use of Matlab is offered as 18-st-2030 Matlab Grundkurs.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

MSc etit, MSc iST, MSc Wi-etit, MSc CE

7 Grade bonus compliant to §25 (2)

Notenverbesserungen bis zu 0,4 nach APB §25(2) durch Bonus für regelmäßig besuchte Übungs-/Praktikumstermine und mindestens einmaliges Vorrechnen in den Übungen

8 References

- A Géron: Hands on Machine Learning with scikit-learn and Tensorflow, 2017
- Friedman, Hastie, Tibshirani: The elements of statistical learning, 2001
- Koller, Friedmann: Graphical Models, 2009

Courses

	Course Nr. 18-st-2020-vl	**Course name** Machine Learning & Energy		
	Instructor Prof. Dr. rer. nat. Florian Steinke, M.Sc. Tim Christian Janke		**Type** Lecture	**SWS** 2
	Course Nr. 18-st-2020-ue	**Course name** Machine Learning & Energy		
	Instructor Prof. Dr. rer. nat. Florian Steinke		**Type** Practice	**SWS** 1
	Course Nr. 18-st-2020-pr	**Course name** Machine Learning & Energy Lab		
	Instructor Prof. Dr. rer. nat. Florian Steinke, M.Sc. Tim Christian Janke		**Type** Internship	**SWS** 1

Module name Machine Learning in Information and Communication Technology (ICT)					
Module Nr. 18-kp-2110	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Anja Klein		

1 Content

The module provides an introduction to the emerging field of machine learning from an engineering perspective. Important models and learning methods are presented and exemplified through problems from information and communication technology.

- Fundamentals of probability theory and multivariate statistics
- Taxonomy of machine learning problems and models (supervised, unsupervised, generative, discriminative)
- Regression and classification: theory, methods and ICT applications
- Dimensionality reduction, clustering and big data analytics: methods and application in communications and signal processing
- Probabilistic graphical models: categories, inference and parameter estimation
- Fundamentals of Bayesian inference, Monte Carlo methods, Bayesian non-parametrics
- Fundamentals of convex optimization: Solution methods and application in communications
- Approximate algorithms for scalable Bayesian inference; application in signal processing and information theory (e.g. decoding of LDPC codes)
- Hidden Markov models (HMM): Theory, Algorithms and ICT applications (e.g. Viterbi decoding of convolutional codes)
- High-dimensional statistics (“large p small n” setting), learning dependency structure in high-dimensional data, learning causality relations from observational data.
- Sparse estimation, random projections, compressive sensing: Theory and applications in signal processing
- Deep neural networks (deep learning): Models, learning algorithms, libraries and ICT applications

2 Learning objectives / Learning Outcomes

Students are able to interpret and categorize specific engineering problems from the ICT domain in terms of machine learning problems.
They are able to reduce such problems to standard machine learning problems and are able to determine suitable solution methods for them.
They are able to implement all necessary algorithms from scratch, but they are also familiar with the state-of-the-art libraries in machine learning.
They are able to determine the involved computational complexity of a method and choose an appropriate solution algorithms based on application constraints.
They are able to apply the acquired methods to other domains, such as data analysis in biomedical engineering, analysis of social network data, etc.

3 Recommended prerequisite for participation

Good command of Matlab (for instance knowledge from course 18-st-2030 Matlab Grundkurs) and engineering mathematics

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

MSc etit, BSc/MSc iST, MSc iCE, MSc CE

7	**Grade bonus compliant to §25 (2)**			
8	**References** • Kevin P. Murphy. Machine Learning – A probabilistic perspective, MIT Press, 2012 • Christopher M. Bishop. Pattern recognition and Machine Learning, Springer, 2006 • Peter Bühlmann und Sara van de Geer. Statistics of high-dimensional data – Methods, theory and applications, Springer, 2011			
Courses				
	Course Nr. 18-kp-2110-vl	**Course name** Machine Learning in Information and Communication Technology (ICT)		
	Instructor Prof. Dr. techn. Heinz Köppl, Prof. Dr.-Ing. Anja Klein, Prof. Dr.-Ing. Abdelhak Zoubir, Prof. Dr.-Ing. Marius Pesavento		**Type** Lecture	**SWS** 2
	Course Nr. 18-kp-2110-pr	**Course name** Machine Learning in Information and Communication Technology (ICT) Lab		
	Instructor Prof. Dr. techn. Heinz Köppl, Prof. Dr.-Ing. Anja Klein, Prof. Dr.-Ing. Abdelhak Zoubir, Prof. Dr.-Ing. Marius Pesavento		**Type** Internship	**SWS** 1
	Course Nr. 18-kp-2110-ue	**Course name** Machine Learning in Information and Communication Technology (ICT)		
	Instructor Prof. Dr. techn. Heinz Köppl, Prof. Dr.-Ing. Anja Klein, Prof. Dr.-Ing. Abdelhak Zoubir, Prof. Dr.-Ing. Marius Pesavento		**Type** Practice	**SWS** 1

Module name					
Lighting Technology I					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-kh-2010	5 CP	150 h	90 h	1	WiSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Khanh Quoc Tran		

1	**Content** Structure and functionality of the human eye, terms and unit in lighting technology, photometry, radiometric and photometric properties of materials, filters, physiology of vision, colour theory, lighting, light sources. Measurement of luminous flux, luminous intensity, illuminance, luminance, determination of the spectral responsivity function of the human eye, colorimetry colour rendering, colour as traffic signals, measuring of optical material characteristics, LED properties
2	**Learning objectives / Learning Outcomes** To list and connect terms, units and radiometric and photometric properties of materials in lighting technology, to describe and understand structure and functionality of the human eye and the physiology of vision, to illustrate basics of lighting, measuring methods and application. Being able to measure base items in lighting technology, applying knowlegde of lighting and enhance them with experiments. Developing a better understanding for light and color.
3	**Recommended prerequisite for participation** MSc ETiT, MSc Wi-ETiT, MSc MEC
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Script for lecture: Lighting Technology I Excersisebook: laboratory: lighting technology I

Courses

Course Nr.	**Course name**		
18-kh-2010-vl	Lighting Technology I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Khanh Quoc Tran		Lecture	2
Course Nr.	**Course name**		
18-kh-2010-pr	Lighting Technology I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Khanh Quoc Tran		Internship	2

Module name					
Introduction to Spintronics					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-me-2020	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr. rer. nat. Markus Meinert		

1 Content

The lecture covers the following subjects:

- Basics of atomic physics (structure of the atoms, electron hull)
- Basics of solid state physics (crystalline materials)
- Introduction to electron transport in solids (classical treatment, band structures)
- Basic notions and simple models of magnetism
- Magnetism in thin films
- Spin-dependent electronic transport
- Magnetoresistive effects, anisotropic magnetoresistance
- Giant magnetoresistance (GMR)
- Tunneling magnetoresistance (TMR)
- Spin-Transfer Torque
- Magnetic microwave oscillators
- Spin-Hall effect and other spin-orbit effects
- Materials for spintronics (ferromagnets, antiferromagnets)
- Magnetic data storage
- Spintronic devices as sensors
- Magnetic random-access memory (MRAM)

2 Learning objectives / Learning Outcomes

The students learn fundamental concepts of spintronics, from properties of magnetic materials to the design and application of spintronic devices in data storage and magnetic sensing. The students acquire the competence to make use of spintronic devices in applications. They further acquire the competence to understand current scientific literature and to dive deeper into the field.

3 Recommended prerequisite for participation

Module 11-01-6419 Materials of Electrical Engineering

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Duration: 120 min, Standard Grading System)

The examination takes place in form of a written exam (duration: 120 minutes). If one can estimate that less than 16 students register, the examination will be an oral examination (duration: 45 min.). The type of examination will be announced in the beginning of the lecture.

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

7 Grade bonus compliant to §25 (2)

Yes

8 References

- A script will be made available electronically
- Coey, Magnetism and Magnetic Materials, 2009, Cambridge University Press
- Skomski, Simple Models of Magnetism, 2008, Oxford University Press
- Felser, Fecher, Spintronics: From Materials to Devices, 2013, Springer
- Dietl, Awschalom, Kaminska, Ohno, Spintronics, 2008, Academic Press
- Blachowicz, Ehrmann, Spintronics, 2019, de Gruyter
- Tsymbal, Zutic, Spintronics Handbook, Volume One: Metallic Spintronics, 2019, CRC Press
- Xu, Awschalom, Nitta, Handbook of Spintronics, 2016, Springer

Courses

Course Nr.	**Course name**		
18-me-2020-vl	Introduction to Spintronics		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Markus Meinert		Lecture	3
Course Nr.	**Course name**		
18-me-2020-ue	Introduction to Spintronics		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Markus Meinert		Practice	1

Module name					
Data Science I					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-zo-2110	5 CP	150 h	90 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Abdelhak Zoubir		

1 Content

The course covers the following topics:

- Python programming basics
- Data science introduction
- Data storage and formats
- Data exploration and visualization
- Statistical methods and inference
  - Descriptive statistics (uni & bivariate)
  - Inferential statistics
- Feature extraction
  - Time Series Data
  - Image data
  - Audio data
- Statistical learning
  - Cross-validation, overfitting, annotation
  - Regression
  - Classification

2 Learning objectives / Learning Outcomes

The course provides a full introduction to data science with an emphasis on hands-on examples. Students will acquire relevant knowledge of the whole data science chain: From storage/acquisition to statistical inference to visualization. It also serves as an introductory course to the Data Science project seminar.

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Duration: 90 min, Standard Grading System)

In general, the examination takes place in form of a written exam (duration: 90 minutes). If up to 15 students register, there will will be an oral examination (duration: 45 min.). The type of examination will be announced within one working week after the end of the examination registration phase.

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

7 Grade bonus compliant to §25 (2)

Yes

8 References

- Lecture notes and slides can be downloaded here:
  - http://www.spg.tu-darmstadt.de
  - moodle

- Further reading:
  - Wes McKinney: Python for Data Analysis, O'Reilly, 2017
  - Christopher M. Bishop: Pattern Recognition and Machine Learning, 2011
  - James, Witten, Hastie and Tibshirani, Introduction to Statistical Learning, Springer, 2017

Courses

Course Nr.	**Course name**		
18-zo-2110-vl	Data Science I		
Instructor		**Type**	**SWS**
Dr.-Ing. Christian Debes		Lecture	2

Course Nr.	**Course name**		
18-zo-2110-ue	Data Science I		
Instructor		**Type**	**SWS**
Dr.-Ing. Christian Debes		Practice	2

2.3 SAE III: Practical courses, project seminars and seminars

Module name Product Development Methodology III					
Module Nr. 18-bu-2125	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 105 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Ph.D. Thomas Peter Burg		

1	**Content** Practical experiences by using methodical procedures in the development of technical products. In addition teamwork, verbal and written representation of results and the organisation of development. Work in a project team and organize the development process independendly.
2	**Learning objectives / Learning Outcomes** Applying the development methodology to a specific development project in a team. To do this, students can create a schedule, can analyze the state of the art, can compose a list of requirements, can abstract the task, can work out the sub-problems, can seek solutions with different methods, can work out optimal solutions using valuation methods, can set up a final concept, can derive the parameters needed by computation and modeling, can create the production documentation with all necessary documents such as bills of materials, technical drawings and circuit diagrams, can build up and investigate a laboratory prototype and can reflect their development in retrospect.
3	**Recommended prerequisite for participation** Product Development Methodology I
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Script: Development Methodology (PEM)

Courses

	Course Nr. 18-bu-2125-pj	**Course name** Product Development Methodology III		
	Instructor Prof. Ph.D. Thomas Peter Burg, Prof. Dr.-Ing. Khanh Quoc Tran, Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr. Mario Kupnik		**Type** Project Seminar	**SWS** 3

Module name					
Product Development Methodology IV					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-kh-2125	5 CP	150 h	105 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Khanh Quoc Tran		

1	**Content** Practical experiences by using methodical procedures in the development of technical products. In addition teamwork, verbal and written representation of results and the organization of development. Work in a project team and organize the development process independently.
2	**Learning objectives / Learning Outcomes** Applying the development methodology to a specific development project in a team. To do this, students can create a schedule, can analyze the state of the art, can compose a list of requirements, can abstract the task, can work out the sub-problems, can seek solutions with different methods, can work out optimal solutions using valuation methods, can set up a final concept, can derive the parameters needed by computation and modeling, can create the production documentation with all necessary documents such as part lists, technical drawings and circuit diagrams, can build up and investigate a laboratory prototype and can reflect their development in retrospect.
3	**Recommended prerequisite for participation** Product Development Methodology I
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Script: Development Methodology (PEM)

Courses

Course Nr.	Course name		
18-kh-2125-pj	Product Development Methodology IV		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Khanh Quoc Tran, Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr. Mario Kupnik, Prof. Ph.D. Thomas Peter Burg		Project Seminar	3

Module name Electromechanical Systems Lab					
Module Nr. 18-kn-2090	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content** Electromechanical sensors, drives and actuators, electronic signal processing mechanisms, systems from actuators, sensors and electronic signal processing mechanism.
2	**Learning objectives / Learning Outcomes** Elaborating concrete examples of electromechanical systems, which are explained within the lecture EMS I+II. The Analyzing of these examples is needed to explain the mode of operation and to gather characteristic values. On this students are able to explain the derivative of proposals for the solution. The aim of the 6 laboratory experiments is to get to know the mode of operation of the electro- mechanical systems. The experimental analysis of the characteristic values leads to the derivation of proposed solutions.
3	**Recommended prerequisite for participation** Bachelor ETiT
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc WI-ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Laboratory script in Electromechanical Systems

Courses

	Course Nr. 18-kn-2090-pr	**Course name** Electomechanical Systems Lab		
	Instructor Prof. Dr. Mario Kupnik		**Type** Internship	**SWS** 3
	Course Nr. 18-kn-2090-ev	**Course name** Electomechanical Systems Lab - Introduction		
	Instructor Prof. Dr. Mario Kupnik		**Type** Introductory Course	**SWS** 0

Module name Project Seminar Electromagnetic CAD					
Module Nr. 18-dg-1060	**Credit Points** 8 CP	**Workload** 240 h	**Self study** 180 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Herbert De Gersem		

1	**Content** Work on a more complex project in numerical field calculation using commercial tools or own software.
2	**Learning objectives / Learning Outcomes** Students will be able to simulate complex engineering problems with numerical field simulation software. They are able to estimate modelling and numerical errors. They know how to present the results on a scientific level in talks and a paper. Students are able to organize teamwork.
3	**Recommended prerequisite for participation** Good understanding of electromagnetic fields, knowledge about numerical simulation methods.
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 20 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Course notes “Computational Electromagnetics and Applications I-III”, further material is provided.

Courses

Course Nr. 18-dg-1060-pj	**Course name** Project Seminar Electromagnetic CAD		
Instructor Prof. Dr.-Ing. Herbert De Gersem, Prof. Dr. rer. nat. Sebastian Schöps		**Type** Project Seminar	**SWS** 4

Module name Project Seminar Design for Testability					
Module Nr. 18-ho-2130	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Learning advanced Methods for Testing Microchips after Manufacturing and Practical Application in small Design Scenarios, Final Presentation
2	**Learning objectives / Learning Outcomes** Learning advanced Methods for Testing Microchips after Manufacturing and Practical Application in small Design Scenarios, Final Presentation
3	**Recommended prerequisite for participation** Lecture “Advanced Digital Integrated Circuit Design”
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Slide Copies

Courses

Course Nr. 18-ho-2130-pj	**Course name** Project Seminar Design for Testability		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Project Seminar	**SWS** 3

Module name Seminar Integrated Electronic Systems Design A					
Module Nr. 18-ho-2160	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Research oriented Formulation of a Topic within the area of Microelectronics System Design; Creation of a written Documentation and Presentation; Team Work
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to 1. gain a deep understanding of the chosen research subject in the field of integrated electronic systems, 2. write an essay on the chosen subject in a comprehesive form and present the outcome to an audience
3	**Recommended prerequisite for participation** Advanced Digital Integrated Circuit Design, CAD Methods, Computer Architectures, Programming Know-How
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 45 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Topic-oriented Materials will be provided

Courses

Course Nr. 18-ho-2160-se	**Course name** Seminar Integrated Electronic Systems Design A	
Instructor Prof. Dr.-Ing. Klaus Hofmann	**Type** Seminar	**SWS** 2

Module name Advanced Integrated Circuit Design Lab					
Module Nr. 18-ho-2120	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Practical Design Tasks in Full Custom Design of Digital or Analog Ciruits using State-of-the-Art Commercial CAD Tools
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to 1. develop and verify transistor circuitry using Cadence 2. simulate logic and analog circuits (Pre- and Postlayout) 3. draw, verify and extract layout
3	**Recommended prerequisite for participation** Lecture “Advanced Digital Integrated Circuit Design” or “Analog Integrated Circuit Design”
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** ADIC Lecture Slide Copies; John P. Uyemura: Fundamentals of MOS Digital Integrated Circuits; Neil Weste et al.: Principles of CMOS VLSI Design

Courses

Course Nr. 18-ho-2120-pr	**Course name** Advanced Integrated Circuit Design Lab		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Internship	**SWS** 3

Module name HDL Lab					
Module Nr. 18-ho-1090	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Realisation of a VHDL- or Verilog-based VLSI System Design Project in a Team with industrial constraints
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to 1. design, optimize and verify a complex digital system (e.g. a pipelined CPU or signal processor) using Verilog or VHDL, 2. synthesize the HDL description using commercial CAD software to a gate level description
3	**Recommended prerequisite for participation** Mandatory Prerequisite: Lecture Computer Aided Design for System on Chips, At least one high-level Programming Language, Basic Know-How Linux/Unix, Computer Architectures
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc/MSc ETiT, BSc/MSc Wi-ETiT, MSc iCE, BSc/MSc iST, BSc/MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture slides „HDL: Verilog and VHDL“

Courses

Course Nr. 18-ho-1090-pr	**Course name** HDL Lab	
Instructor Prof. Dr.-Ing. Klaus Hofmann	**Type** Internship	**SWS** 3

Module name Project seminar Applications of Lighting Engineering					
Module Nr. 18-kh-2051	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 105 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Khanh Quoc Tran		

1	**Content** The project seminar deals with the following subjects: automotive lighting, interior lighting, exterior lighting; generation, perception and cognition of the visual stimulus (luminaires, displays, projection); LED/OLED technology; physical and psychophysical light measurement; illuminating engineering, color perception.
2	**Learning objectives / Learning Outcomes** The objective of this project seminar is the practice oriented implementation of the material learned during the lectures in form of a project work. Via communication of the interdisciplinary way of thinking of the lighting engineer, students should carry out autonomous project work on their own or in a team.
3	**Recommended prerequisite for participation** Lighting Technology I-II (desireable)
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iST, MSc WI-ETiT, MSc MEC, MSc MPE, MSc Phys
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture notes of Lighting Technology I (Khanh); Lecture slides of our Laboratory; Book “LED Lighting: Technology and Perception” (Khanh et al., Wiley); Book „Farbwiedergabe“ (Khanh et al., Pflaum-Verlag); specific literature depending on the topic, publications.

Courses

Course Nr. 18-kh-2051-pj	**Course name** Project seminar Applications of Lighting Engineering	
Instructor Prof. Dr.-Ing. Khanh Quoc Tran	**Type** Project Seminar	**SWS** 3

Module name Project Seminar Design for Additive Manufacturing – Interdisciplinary view of potentials and impacts of a new technology					
Module Nr. 18-ho-2220	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1 Content

In the tutorial, potentials and effects on products which result from the technology of additive manufacturing are demonstrated from the perspectives of the departments of mechanical engineering, electrical engineering, civil engineering and economics. Here, the following topics are addressed:

- Function integration, topology optimization, optimization of electronic components, effects of the manufacturing technology on business models.

The participating students first deepen the contents of the introductory lesson by using the provided literature and then apply it in teams using a wind turbine. In this case, a existing CAD data set of a wind turbine is used, to which an exercise task is performed for each of the mentioned topics. Software, for example Siemens NX or INSPIRE, is used to support the modeling and simulation of individual areas of the wind turbine necessary for the performance of the exercises. The results of the exercises are then printed using 3D printers, so that each team has his own optimized wind turbine using the potentials of additive manufacturing at the end of the tutorial.

2 Learning objectives / Learning Outcomes

On successful completion of this module, students should be able to:

- Explain the entire process chain of additive manufacturing.
- Explain the steps which are necessary for the virtual preparation of 3D printing (component design, slicing, construction of support structures, nesting) such as the steps for preparation of the printer itself, the printing process and the post processing.
- Highlight the benefits of additive manufacturing by focusing on function integration, topology optimization, and electronic component optimization, and mapping the impact of the manufacturing process on business models.
- Adapt additive manufacturing using the example of a topology-optimized wind turbine tower using software (Siemens NX, INSPIRE, etc.).
- To differentiate the perspectives of additive manufacturing of the different departments and to estimate the potentials.

3 Recommended prerequisite for participation

None

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Written/Oral Examination, Duration: 20 min, Standard Grading System)

Written report and oral exam with discussion, 20 minutes for each topic

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

MSc etit, MSC MEC, MSc MPE

7 Grade bonus compliant to §25 (2)

8 References

Slides (moodle) including basic literature

Courses

Course Nr.	Course name		
18-ho-2220-pj	Project Seminar Design for Additive Manufacturing – Interdisciplinary view of potentials and impacts of a new technology		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr. Alexander Kock, Prof. Dr.-Ing. Ulrich Knaack, Prof. Dr.-Ing. Eckhard Kirchner		Project Seminar	4

Module name					
Project seminar Advanced Applications of Lighting Engineering					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-kh-2052	5 CP	150 h	105 h	1	WiSe/SoSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Khanh Quoc Tran		

1	**Content** For the project seminar a question from the following topics can be worked on: automotive lighting, light for the autonomous car, interior lighting, exterior lighting; smart lighting, human centric lighting (hcl); horticultural lighting; generation, perception and cognition of the visual stimulus (luminaires, displays, projection); LED/OLED technology; physical and psychophysical light measurement; illuminating engineering, color perception, virtual reality tests for light-simulation.
2	**Learning objectives / Learning Outcomes** The objective of this project seminar is the practical implementation of the knowledge acquired during the study in the form of a project work. Students participate on their own or in a team. In this project seminar, students learn to plan, implement and validate lighting issues. The basics of the lecture and the project seminar 'Applications of Lighting Engineering' are applied and deepened. This usually includes the selection of suitable illuminants, the development of electronic hardware as well as the use of photometric measuring instruments. In addition, the students learn how to abstract questions, communicate project-dependent information as well as present and discuss results.
3	**Recommended prerequisite for participation** Lighting Technology I-II (desireable), Project seminar Applications of Lighting Engineering
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System) To conclude the project, every student has to hold a presentation with a short round of questions and answers and also to deliver a written report about the work and the results. The presentation with exam and the report will be graded according to the fixed guidelines of our Laboratory.
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture notes of Lighting Technology I (Khanh); Lecture slides of our Laboratory; Book "LED Lighting: Technology and Perception" (Khanh et al., Wiley); Book „Farbwiedergabe" (Khanh et al., Pflaum-Verlag); specific literature depending on the topic, publications.

Courses

Course Nr.	Course name		
18-kh-2052-pj	Project seminar Advanced Applications of Lighting Engineering		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Khanh Quoc Tran		Project Seminar	3

Module name					
Project seminar Special Applications of Lighting Engineering					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-kh-2053	8 CP	240 h	195 h	1	WiSe/SoSe
Language			**Module owner**		
German and English			Prof. Dr.-Ing. Khanh Quoc Tran		

1	**Content** For the project seminar a question from the following subject areas can be worked on: Automotive lighting, light for autonomous cars, interior lighting, exterior lighting; smart lighting; human centric lighting (HCL); horticulture lighting; generation, perception and cognition of visual stimuli (luminaires, displays, projection); LED/OLED technology; physical and psychophysical light measurement; illuminating engineering, color perception, virtual reality tests for light-simulation.
2	**Learning objectives / Learning Outcomes** The objective of this project seminar is the practical implementation of the knowledge acquired during the study in the form of research or project work in an interdisciplinary context, which also takes up topics beyond the lectures. Students participate on their own or in a team. In this project seminar, the students learn the approach, implementation and validation or investigation of inter-disciplinary lighting issues. This requires an introduction into topics that go beyond the subject area of the lectures. Usually, this includes the selection of suitable illuminants, the development of electronic hardware, the use of photometric measuring instruments as well as the conception, execution and evaluation of studies. In addition, students learn to abstract questions, to develop research questions, to com-municate information depending on the project, and to present and discuss results.
3	**Recommended prerequisite for participation** Lighting Technology I-II (desireable), Project seminar Applications of Lighting Engineering (recommended)
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System) At the beginning of the project, a short introductory presentation has to be held followed by a technical discussion. Each student involved in the project has to conclude the project with a presen-tation followed by a short question and answer session. Every student has to deliver a written re-port about the work and the results. The final presentation with exam and the report will be graded according to the fixed guidelines of the institute.
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture notes of Lighting Technology I (Khanh); Lecture slides of our Laboratory; Book "LED Lighting: Technology and Perception" (Khanh et al., Wiley); Book „Farbwiedergabe" (Khanh et al., Pflaum-Verlag); specific literature depending on the topic, publications.

Courses

Course Nr.	Course name		
18-kh-2053-pj	Project seminar Special Applications of Lighting Engineering		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Khanh Quoc Tran		Project Seminar	3

Module name Data Science II					
Module Nr. 18-zo-2120	**Credit Points** 8 CP	**Workload** 240 h	**Self study** 180 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir		

1 Content

The course covers the following topics:

- Data Science Advanced Methods
- Data Management + Big data frameworks
- Statistical Learning
  - Recommender Systems
  - Deep Learning
  - Unsupervised Learning
  - Text data analysis

- Final application project. Flexibility to choose from list of projects or come up with own project. Examples:
  - Sound classification
  - Heart rate analysis
  - Activity recognition with acceleration data
  - Hyperspectral data
  - Image classification
  - Health survey

2 Learning objectives / Learning Outcomes

This seminar provides an advanced understanding of data science with an emphasis on hands-on projects. Students will get to know latest data science technologies – from big data to advanced machine learning and apply them in a real-world project.

3 Recommended prerequisite for participation

Data Science I (Lecture)

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Written/Oral Examination, Duration: 90 min, Standard Grading System)

In general, the examination takes place in form of a written exam (duration: 90 minutes). If up to 14 students register, there will will be an oral examination (duration: 45 min.). The type of examination will be announced in the first lecture. Possible types include a project presentation, etc.

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

7 Grade bonus compliant to §25 (2)

8 References

Lecture notes and slides can be downloaded here:

- http://www.spg.tu-darmstadt.de
- Moodle platform

Further reading:

- Wes McKinney: Python for Data Analysis, O'Reilly, 2017
- Christopher M. Bishop: Pattern Recognition and Machine Learning, 2011
- James, Witten, Hastie and Tibshirani, Introduction to Statistical Learning, Springer, 2017

Courses

Course Nr.	**Course name**		
18-zo-2120-se	Data Science II		
Instructor		**Type**	**SWS**
Dr.-Ing. Christian Debes		Seminar	4