TECHNISCHE UNIVERSITÄT DRESDEN

Faculty Electrical and Computer Engineering

Current Study Guide for the consecutive Master's program Nanoelectronic Systems Summer Term 2024

Please note: This is an English translation of the German original. **Only the German version is legally binding.**

Appendix 1
Module Descriptions

Required modules

Module number	Module name	Lecturer in charge
NES-12 ASW-14.1	Academic and Scientific Work	Dean of studies
Contents and objectives	After completion of the module students have the key competencies for the academic and scientific work. They can deal critically with scientific texts or pass on their knowledge to others and monitor their learning process. This includes understanding the essential content of scientific texts, their integration into the current scientific context, the critical reflection of social, economic and cultural impact as well as their representation and presentation. To stimulate and to enable the development of knowledge among learners the students have acquired knowledge of the general academic teaching and can apply this.	
Modes of teaching and learning	The module consists of 3 hours per week lectures, tutorials, labs, or seminars and self study. The courses are choosen in the specified amount from the catalog "Wissenschaftliches Arbeiten (Scientific Work)". The catalog is given inclusive of the required examinations at the beginning of the semester faculty usually known.	
Prerequisites		
Usability	The module is a required module in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module test is passed. The assessment consists of the prescribed examinations according to the catalog "Wissenschaftliches Arbeiten (Scientific Work)".	
Credit points and grades	4 credit points can be obtained by the module. The grade is derived from the unweighted mean of the grades of the individual examinations.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 120 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 10 01-14.1	Fundamentals of Estimation and Detection	Dr. Rave
Contents and objectives	After completion of the module the students know the key approaches for parameter estimation and detection as well as the basics of linear estimation techniques and of memory-afflicted systems. They understand the different mathematical models and approaches that the current methods are based, and thus they are able to select and apply the appropriate procedures for various practical scenarios. Students can evaluate different estimators / detectors on the basis of quality criteria.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours per week tutorials and self-study.	
Prerequisites	Knowledge in system theory and basic knowledge in stochastic on bachelor level	
Usability	The module is a required module of the branch of study Nanoelectronic in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 120 minutes.	
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 180 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 10 03-14.1	Hardware/Software Codesign	Prof. Fettweis
Contents and objectives	The module content includes: - Methods and different aspects of hardware and software implementation of embedded systems (including telecommunications). - Mutual influence of both designs (co-design) in order to optimize the circuit design, - New arallel processing concepts through massive structure reduction towards the "Nano Scale". Objectives: After completing this module, students have an overview of current hardware systems, specifically the various hardware platforms for software implementation of digital signal processing algorithms, and can evaluate these with respect to various criteria (eg, flexibility, power consumption). Students can derive from algorithms the hardware requirements in compliance with the requirements of flexibility for the hardware and software components. They know strategies to enhance performance and minimize power consumption and can apply them safely	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 1 hour per week tutorials and self-study.	
Prerequisites		
Usability	The module is a required module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems. The module creates the prerequisites for the module Hardware / Software Codesign Lab.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 120 minutes, if the number of registered students exceeds 16. With up to 16 registered students the written exam is replaceed by an oral exam as individual exam worth 20 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty.	
Credit points and grades	4 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every summer semester.	
Workload	The total effort is 120 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-11 06 01-19.1	Lab Sessions	Prof. Dr. Christof Fetzer
Contents and objectives	This module provides the practical skills and abilities in the field of embedded system design and semiconductor manufacturing. Participants gain experience in teamwork and project work and deepen their skills in lecture and presentation techniques. After completing the module the students have a first state of knowledge on issues of embedded system design and have some experience with the most important process steps in semiconductor manufacturing.	
Modes of teaching and learning	The module consists of 3 hours per week practical training and self-study.	
Prerequisites		
Usability	The module is a required module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of two lab protocols. A collection of exercises has to be solved as exam prerequisites.	
Credit points and grades	5 credit points can be obtained by the module. The module grade is the unweighted mean of the grades of the lab protocols.	
Frequency	The module is offered every academic year beginning in the winter semester.	
Workload	The total effort is 150 hours.	
Duration	The module takes two semesters.	

Module number	Module name	Lecturer in charge
NES-11 06 02-14.1	Principles of Dependable Systems	Prof. Dr. Christof Fetzer
Contents and objectives	After the completion of this module, students are able to design and to implement highly reliable and secure systems. Special skills they acquired for the design of distributed protocols for critical systems, due the variety of possible error and failure types in this area. Based on their theoretical knowledge, students can design effective solutions to practical scenarios.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours per week tutorials and self-study.	
Prerequisites	Participants should be familar with the basics of design, development and operation of computer-based systems (bachelor level).	
Usability	The module is a required module of the branch of study Nanoelectronics in the master’s program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 60 minutes, if the number of registered students exceeds 10. With up to 10 registered students the written exam is replaceed by an oral exam as individual exam worth 30 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty. A collection of exercises has to be solved as exam prerequisites.	
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 180 hours.	
Duration	The module takes one semester.	

Module number	**Module name**	**Lecturer in charge**
NES-12 PW-14.1	Project Work	Dean of studies
Contents and objectives	Contents: - Research, development, modeling, analysis, planning, design, system design, programming, - Implementation and coding, operation, maintenance, verification and testing, commissioning, Outcomes: The students have expertise in handling complex problems in modern engineering professional practice and to document and present their results. They have social skills of professional communication, project and product management.	
Modes of teaching and learning	The module consists of a project including self-study.	
Prerequisites		
Usability	The module is a required module of the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of the project report in the amount of 36 days and a presentation of 15 minutes duration..	
Credit points and grades	10 credit points can be obtained by the module. The module grade is the weighted mean of the grades of the two examinations, in which the grade of project report is weighted with 4/5 and the grade of the presentation is weighted with 1/5.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 300 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 08 02-14.1	Radio Frequency Integrated Circuits	Prof. Ellinger
Contents and objectives	The module content includes: - High frequency integrated circuits for high speed wireless communications such as low noise amplifiers, power amplifiers, mixers, oscillators on basis of active and passive devices, as well as complete radio frontends and architectures. - Aggressively scaled CMOS and BiCMOS, Moore than Moore (e.g. FinFET, SOI, strained silicon) and Beyond more Moore (silicon nano wire, CNT and organic) technologies from circuit design perspective. Qualification goals: After completion of the module – the students obtain competences regarding Methods for the design of analog high frequency integrated circuits. They know the basic circuits and architectures of the systems. – The students master the analysis and optimization of these circuits. – The students get to know design tools for circuits – The students use the English technical language in the field of high-frequency circuits	
Modes of teaching and learning	The module consists of 3 hours per week lectures, 1 hour per week tutorials, 2 hours per week practical training and self-study.	
Prerequisites	Basic knowledge in circuit design on bachelor level is required.	
Usability	The module is a required module of the branch of study Nanoelectronics in the master’s program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment is a written exam in the amount of 120 minutes. The exam can be taken in German or English.	
Credit points and grades	7 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every summer semester.	
Workload	The total effort is 210 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 12 02-19.1	Semiconductor Technology	Prof. Mannsfeld
Contents and objectives	The module contains the technological basics for the fabrication of micro- and nano devices as well as the manufacturing concepts for integrated circuits. Students have the ability – to describe the operation of individual technologies for the production of micro- and nano-devices, – to work with basic principles for the production and miniaturization of components and circuits, – to add the individual technologies to complex process flows together and explain their interaction.	
Modes of teaching and learning	The module consists of 6 hours per week lectures and self-study.	
Prerequisites		
Usability	The module is a required module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consist of a written exam in the amount of 120 minutes, if the number of registered students exceeds 20. With up to 20 registered students the witten exam will be replace by an oral exam as an individual exam worth 30 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty.	
Credit points and grades	9 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every academic year beginning in the winter semester.	
Workload	The total effort is 300 hours.	
Duration	The module takes two semesters.	

Required elective modules

Module number	Module name	Lecturer in charge
NES-E-ACSR	Adaptive Computing Systems for Robotics	Prof. Dr.-Ing. Diana Göhringer diana.goehringer@tu-dresden.de
Objectives	After successful completion of this module, the participants have qualifying knowledge in the areas design and programming of modern embedded systems for robotic applications and basic knowledge in the field of robotics in the areas of perception, localization, planning and multi-robot collaboration tasks. Further, they have practical skills in the use of Robotics Operating System (ROS), Embedded Linux and modern embedded FPGA systems, such as the Xilinx Zynq System-on-Chip.	
Contents	The module provides an overview and special knowledge in the fields of FPGA-based computing accelerator designs for robotics and their optimized techniques. The course focuses on how FPGAs are used in robotic perception, localization and planning. In addition to the individual robotic tasks mentioned above, the course will also describe how these can be combined into robotic products, such as autonomous vehicles and mobile robots. The practical course accompanying the lecture includes practical experience in the above-mentioned subject area through hands-on experience with robotics and reconfigurable platforms.	
Modes of teaching and learning	The module includes 2 SWS lectures and 2 SWS exercises as well as self-study.	
Prerequisites	Programming knowledge in C/C++ as well as basic knowledge and skills in technical computer science are required, in particular the participants should be familiar with the basics at Bachelor level.	
Usability	The module is an elective module in the Nanoelectronic Systems Master's program.	
Requirements for the award of credit points	The credit points are earned when the module examination has been passed. For up to 10 registered participants, the module examination consists of an oral examination performance as an individual examination lasting 20 minutes. If there are more than 10 participants, the examination consists of a written examination lasting 60 minutes. The type of concrete examination will be determined by the module supervisor at the end of the examination registration period and will be publicly announced in accordance with faculty practice.	
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every summer semester.	
Workload	The total effort is 180 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-E-AdLsy	Adaptive Laser Systems	Prof. Dr.-Ing. habil. Jürgen Czarske juergen.czarske@tu-dresden.de
Objectives	The students can describe, employ and evaluate adaptive laser systems. They have mastered the fundamentals in system design for modern laser sensors.	
Contents	The module contains - Laser measurement systems (fundamental physics, gaussian beam, interferometry, fourier optics, fiber sensors) - Experimental application of laser sensors	
Modes of teaching and learning	2 hours per week lectures, 1 hour per week lab work, 1 hour per week exercises, and self-study	
Prerequisites	Prior knowledge is required in - Physics (at least A levels) - System theory	
Usability	The module is an elective module in the Master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of an oral exam as individual exam of 20 minutes and a lab course.	
Credit points and grades	5 credit points can be obtained by the module. The module grade is the weighted mean of the grade of the oral exam weighted by 3/4 and the grade of the lab course weighted by 1/4.	
Frequency	The module is offered every summer semester.	
Workload	The total effort is 150 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 10 05-20.1	Antennas and Radar Systems	Prof. Dr.-Ing. Dirk Plettemeier
Objectives	After completion of the module, the students are able to describe important antenna parameters and evaluate different antenna types in this context. They are able to synthesize the radiation characteristics of antenna arrays and present radiation mechanisms of certain antenna types. They know how to compare simulation and measurement data of a self-designed and measured antenna. Furthermore, they are able to classify antenna models from the current literature. The students are able to analyze the radar equation and to explain basic radar principles. They are in the position to classify an unknown radar system and to derive its functionality from a block diagram. They are capable of evaluating the performance and limitations of radar systems and are skilled in designing a radar system for a given problem.	
Contents	The content of the module focuses on the fundamentals of antenna theory (e.g. parameter, antenna arrays, linear, aperture, patch, slot, on-chip antennas) and of Radar Systems (e.g. radar equation, pulse/pulse Doppler, CW, SFCW, FMCW, PRN, SAR).	
Modes of teaching and learning	The module consists of 4 hours per week lectures, 2 hours per week tutorials and self-study.	
Prerequisites	Knowledge as it can be obtained from the module Radio Frequency Technology is advantageous.	
Usability	The module is a required elective module in the Master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of an oral exam as individual exam worth 45 minutes.	
Credit points and grades	7 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every summer semester.	
Workload	The total effort is 210 hours.	
Duration	The module takes one semester.	

Modul number	Module name	Course supervisor
NES-E-AJCAS	Applied Joint Communications and Sensing Systems	Prof. Dr.-Ing. Dr. h.c. Gerhard Fettweis gerhard.fettweis@tu-dresden.de
Objectives	Upon successful completion of the module, students will acquire a comprehensive understanding of joint communications and sensing technology at the system level. They will possess the ability to interpret the implications of key theorems and analyze how the final equations interpret the operations and characteristics of JCAS. Furthermore, the module aims to furnish students with an overview of the current state of the art in JCAS. By gaining a strong foundation in the fundamental principles, technologies, and applications of JCAS, students will be sufficiently equipped to actively contribute to the progress and implementation of JCAS solutions across various scenarios.	
Contents	The module kicks off by providing a concise overview of the fundamental concepts in communications and sensing technologies, as covered in the corresponding course "JCAS for 6G networks". It then proceeds to delve into the practical applications and use cases of these concepts, including vehicular scenarios. Subsequently, it conducts an in-depth analysis of JCAS classical and adaptive waveforms. In the realm of adaptive waveform design, it explores leveraging prior knowledge obtained from previous environmental scans, enabling the JCAS system to enhance its performance to a higher level than achievable with classical. Ultimately, it addresses the application of AI in JCAS, exploring both the challenges and opportunities associated with implementing Deep Learning in sensing and communications networks.	
Modes of teaching and learning	2 hours per week lectures, 2 hours per week exercises, and self-study	
Prerequisites	A basic understanding of Electrical Engineering or Computer Science, along with basic knowledge of mathematics at the Bachelor's level is necessary.	
Usability	The module is an elective module in the Master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam of 90 minutes.	
Credit points and grades	5 credit points can be obtained by the module. The module grade is the grade of the examination.	

Frequency	The module is offered every summer semester.
Workload	The total effort is 150 hours.
Duration	The module takes one semester.

Module number	Module name	Lecturer in charge
NES-12 10 20	Communication Networks 3	Prof. Dr.-Ing. F. Fitzek
Contents and objectives	The content of the module includes: 1. tools for investigating the performance of communication systems, in particular the analytical and simulative approach and the exemplary build-up by means of implementation 2. future communication systems, especially planning, analysis and architecture 3. approaches to project-based work, incl. work-structuring and presentation of work results (in writing and verbal) in front of a specialist audience. Qualification objectives: After completion of the module, the students have a thorough understanding of the modeling and performance analysis of communication networks and its protocols. They are able to select and apply appropriate methods of investigation for various problems. The students have learned to look at their tasks in a professional manner, to structure their project in terms of work and time, and to present their results in a public-oriented manner.	
Modes of teaching and learning	4 hours per week lectures, 2 hours per week tutorials and self-study.	
Prerequisites		
Usability	The module is a required elective module in the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 120 minutes and a project report with a scope of 30 hours, if the number of registered students exceeds 15. With up to 15 registered students the written exam is replaced by an oral exam as individual exam worth 30 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty.	
Credit points and grades	7 credit points can be obtained by the module. The module grade is the unweighted mean of the grade of the examination and of the project report.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 210 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 10 02-14.1	Communications	Prof. Dr.-Ing. Dr. h.c. Gerhard Fettweis
Contents and objectives	The module content includes: Signal theory (sine waves, Dirac function, convolution, Fourier transform), linear time-invariant systems (transfer function, impulse response) bandpass signals (real and complex up and downward mixing of signals, equivalent lowpass signal), analog modulation (modulation, demodulation, properties of AM , PM, FM), analog-digital conversion (sampling, signal reconstruction, quantization, sub- and over sampling), digital modulation schemes (modulation methods, matched-filter receiver, bit error probability). Outcomes: After completing this module, students master the basic principles and practical application of communications. The students will be able to understand the basic signal processing in communications systems and to describe them mathematically. They are familiar with the transmission in base band and band-pass area and know the basic analog and digital modulation methods. They understand for simple analog and digital transmission scenarios the impact of noise on the transmission quality.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 1 hour per week tutorials and self-study.	
Prerequisites	It is assumed the knowledge of systems theory for analog and digital systems, algebra, calculus, complex analysis, partial differential equations and probability theory at the bachelor level.	
Usability	The module is a required elective module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 120 minutes.	
Credit points and grades	3 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every summer semester.	
Workload	The total effort is 90 hours.	
Duration	The module takes one semester.	

Module number	**Module name**	**Lecturer in charge**
NES-ET-E-ComLS-23	Computational Laser Systems	Prof. Dr.-Ing. habil. Jürgen Czarske juergen.czarske@tu-dresden.de
Objectives	After completion of the module, the students can describe and design computational optical imaging systems using the knowledge in laser physics, system theory, digital signal processing and Fourier optics conveyed in this module.	
Contents	The module focuses on digital holography and image processing as well as biomedical laser systems and optogenetics. This includes among others: self-parametrization of laser systems, optogentics through scattering tissue, neural networks for signal processing, adaptive optics and diffractive deep neural networks for optical computing with speed of light.	
Modes of teaching and learning	3 hours per week lectures, 1 hour per week exercises, and self-study	
Prerequisites	Basic knowledge of Physics on Bachelor level is recommended.	
Usability	The module is an elective module in the Master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of an oral non-public exam as individual exam of 30 minutes.	
Credit points and grades	5 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 150 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-E-DNNH-23	Deep Neural Network Hardware	Prof. Dr.-Ing. habil. Christian Georg Mayr christian.mayr@tu-dresden.de
Objectives	After completion of the module, students have a profound understanding of the major design decisions for DNN hardware accelerators. They are able to select or specify a suitable accelerator for a given DNN-based application. They have an understanding of the basic steps for deploying DNN on hardware accelerators, and they know optimization techniques for DNN hardware accelerators.	
Contents	The module focuses on the design of hardware accelerators for deep neural networks – DNN-, ranging from architectures to arithmetic building blocks. Aspects of Hardware/ software codesign are also covered, as well as DNN deployment on hardware accelerators. Selected optimization techniques for DNN accelerators and upcoming accelerator approaches are introduced.	
Modes of teaching and learning	2 hours per week lectures, 2 hours per week exercises, and self-study	
Prerequisites	Basic knowledge of deep neural networks and basic understanding on Bachelor level is recommended.	
Usability	The module is an elective module in the Master’s program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam of 90 minutes.	
Credit points and grades	5 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every summer semester.	
Workload	The total effort is 150 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-11 20 19	Design and Programming of Embedded Multicore Architectures	Prof. Göhringer
Objectives	After successful completion of this module, the participants have qualifying knowledge in the areas of design and programming of modern embedded systems and in the area of simulation of embedded multicore architectures. They will also have practical skills in the use of embedded operating systems, such as Embedded Linux or FreeRTOS, on a modern embedded system, such as a Xilinx Zynq System-on-Chip.	
Contents	The module provides overview and special knowledge in the fields of design, simulation, and programming of modern embedded systems consisting of several processors and special accelerators. The lecture-accompanying exercises serve to consolidate the lecture material and include practical experience in the subject area.	
Modes of teaching and learning	The module includes 2 SWS lectures and 2 SWS exercises as well as self-study.	
Prerequisites	Basic knowledge and skills of computer architectures are required, in particular the participants should be familiar with the basics at Bachelor level.	
Usability	The module is an elective module in the Nanoelectronic Systems Master's program.	
Requirements for the award of credit points	The credit points are earned when the module examination has been passed. For up to 10 registered participants, the module examination consists of an oral examination performance as an individual examination lasting 20 minutes. If there are more than 10 participants, the examination consists of a written examination lasting 60 minutes. The type of concrete examination will be determined by the module supervisor at the end of the examination registration period and will be publicly announced in accordance with faculty practice.	
Credit points and grades	6 credit points can be earned through the module. The module grade corresponds to the grade of the examination performance.	
Frequency	The module is offered every summer semester.	
Workload	The total effort is 180 hours.	
Duration	The module takes one semester.	

Modulnummer	Modulname	Verantwortlicher Dozent
NES-12 12 04-14.1	Electromechanical Networks	Prof. Dr.-Ing. habil. Marschner
Objectives	The students – are skilled with the basic methodological and practical knowledge to analyse and to design effectively the dynamic behavior of coupled electromechanical, magnetic and fluidic systems using a circuit representation of the different subsystems including their interactions based on network theory, – master the function and modelling of electromechanical transducers, – can simulate the behavior of electromechanical systems with existing circuit simulation software such as Spice. The students are thus able to use the clear and illustrative analysis methods of electrical networks to develop a better physical understanding and to design physically different subsystems in a closed manner.	
Contents	Module contents are the description of coupled multiphysical subsystems in the form of a common circuit diagram and their behavioral simulation. Simple mechanical, magnetic, fluidic (acoustic), electrical and coupled systems, including their interactions, are analyzed.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 1 hour per week tutorials and self-study.	
Prerequisites	Basic knowledge on bachelor level of electrical circuits, sophomore level mathematics (calculus and elementary linear algebra).	
Usability	The module is an elective module in the master's program "Nanoelectronic Systems".	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of written exam in the amount of 120 minutes.	
Credit points and grades	4 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module will be offered every winter semester.	
Workload	The total effort is 120 hours.	
Duration	The module takes one semester.	
Literature	Lenk, A., Ballas, R.G., Werthschützky, R., Pfeifer, G.: Electromechanical Systems in Microtechnology and Mechatronics	

	- Electrical, Mechanical and Acoustic Networks, their Interactions and Applications, 1st Edition., 2011, ISBN: 978-3-642-10805-1

Module number	Module name	Lecturer in charge
NES-DSE-14-E14	Embedded Hardware Systems Design	Prof. Kumar
Objectives	After successfully completing this module, the participants are able to translate system specifications into executable calculation models using a high specification language and to decode these formal specifications into a register transfer level HDL, which can be implemented on an FPGA.	
Contents	The aim of this module is to understand and practice the principles of complex embedded systems development. The main topics include: embedded systems development methodology; specification and modeling of systems; architectures of embedded systems; deciphering specifications in architectures; rapid prototyping on FPGA platforms.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours per week tutorials and self-study.	
Prerequisites	Basic knowledge of computer architecture and embedded systems is required. Furthermore, knowledge in hardware design, including VHDL and FPGA is an advantage.	
Usability	The module is an elective module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of an oral exam as individual exam worth 30 minutes.	
Retake exams	The exam form for the award of credits corresponds to the regular exam at the first retake exam (WH1). In the case of an approved second re-exam (WH2), the examination is an oral individual exam of 30 minutes.	
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every summer semester.	
Workload	The total effort is 180 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-INF-E-FCPL	Foundations of Certified Programming Language and Compiler Design	Dr.-Ing. Sebastian Ertel sebastian.ertel@barkhauseninstitut.org

Objectives	After completion of the module, students will be able to develop programs with strong guarantees about their properties in order to minimise testing effort and avoid complex runtime errors already during the development process. For this purpose, the participants know the basics of strongly-typed programming languages, so-called dependently-typed languages, and their connection to logic. This knowledge enables the participants to develop programs in programming languages such as Agda or theorem provers such as Coq and to formally prove their properties. The participants know essential proof procedures to formally verify properties of programming languages, compilers and even hardware-related programs.
Contents	The module focuses on the theories of the untyped and typed lambda calculus, type systems with dependent types and their connection to propositional and predicate logic as a basis for the Curry-Howard isomorphism. Other content includes programming with strongly-typed programming languages such as Agda and theorem provers such as Coq. Fundamentals of the properties of programming languages and compilers, their impact on the design process, and proving them formally are other key content. This also includes important proof techniques and formal concepts for defining operational and denotational semantics.
Modes of teaching and learning	2 hours per week lectures, 2 hours per week exercises, and self-study
Prerequisites	Basic knowledge of Programming, Logic, Data Management and Software Technology on Bachelor level is recommended.
Usability	The module is an elective module in the Master's program Nanoelectronic Systems.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of an oral non-public exam as individual exam of 30 minutes.
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the examination.
Frequency	The module is offered every winter semester.
Workload	The total effort is 180 hours.
Duration	The module takes one semester.

Module number	Module name	Lecturer in charge
NES-INF-DSE-20-E-SFT	Foundations of Software Fault-Tolerance	Prof. Dr. Christof Fetzer
Contents and objectives	After the completion of this module, graduates of this module are able to develop and to use mechanisms and systems designs, that address on often than the average as software errors occurring system failures in distributed systems at run time. They have the necessary expertise on the subject of forgiveness and use their expertise to discuss and evaluate current scientific work in this area. The students to have the necessary practical skills with which they can analyze and correct errors in specific application scenarios. They are in a position to use the acquired skills of this module in new, unknown scenarios and apply them to develop effective practical solutions.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours per week tutorials and self-study.	
Prerequisites	Participants should be familar with the basics of design, development and operation of computer-based systems. (bachelor level)	
Usability	The module is a required elective module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of an oral exam of 30 minutes.	
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every summer semester.	
Workload	The total effort is 180 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-INF-DSE-20-M-SE1	Foundations of Systems Engineering	Prof. Dr. Christof Fetzer
Contents and objectives	After completing this module, students are familar with the basics of design, development and operation of computer-based systems. They have an overview of structures of such systems, which usually consist of several hardware components and several layers of software. The students have the necessary knowledge, especially to non-functional aspects of systems, such as reliability and availability, and control mechanisms for providing these non-functional aspects. The students should be able to understand fundamental relationships of the subject and they can use this knowledge during their further studies.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours per week tutorials and self-study.	
Prerequisites	Basic knowledge in the areas of system architecture, modularization and structuring of complex systems (on bachelor level).	
Usability	The module is a required elective module of the branch of study Nanoelectronics in the master’s program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam worth 60 60 minutes. A collection of exercises in the amount of 30 hours has to be solved as exam prerequisites.	
Credit points and grades	5 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 150 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 08 01-20.1	Future Computing Strategies in Nanoelectronic Systems	Prof. Dr. phil. nat. Ronald Tetzlaff
Objectives	After completion of the module, the students have advanced knowledge of future computer strategies which use the functionalities of state-of-the-art nanotechnologies.	
Contents	The content of the module focuses on state-of-the-art computing structures for data processing using innovative nanotechnologies which increase the efficiency of integrated circuits and therefore reach far beyond the age of Moore's law. The following computer architecutures, amongst others, are dealt with in the module: neuromorphic structures, Cross-Point Arrays, Crossbar Arrays, neural networks, and quantum computing.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 1 hour per week tutorials and self-study.	
Prerequisites	Students should have knowledge of higher mathematics, system theory and circuit design on Bachelor level.	
Usability	The module is a required elective module in the Master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 90 minutes if the number of registered students exceeds 5. With up to 5 registered students the written exam can be replaced by an oral exam as individual exam worth 30 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty.	
Credit points and grades	4 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 120 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-30 GLC-14.1	German Language and Culture	
Contents and objectives	Content of the module: German lessons with regional and cultural topics Objective: Knowledge about German everyday language (written and spoken) on A1-Level of the CEFR	
Modes of teaching and learning	The module consists of 4 hours per week language courses and self-study.	
Prerequisites		
Usability	The module is a required elective module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam with the amount of 90 minutes.	
Credit points and grades	4 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 120 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-11 20 20	Hardware Modelling and Simulation	Prof. Göhringer
Objectives	After successful completion of this module, the participants have qualifying knowledge in the areas of simulation, evaluation and verification of digital systems, such as field programmable gate arrays (FPGAs) and in the area of modeling digital systems using SystemC. Further, they have practical skills in programming digital systems using the hardware description language VHDL and experience from sample projects.	
Contents	The module provides overview and special knowledge in the fields of simulation, evaluation and verification of digital systems. The practical course accompanying the lecture includes practical experience in programming digital systems using the hardware description language VHDL and the modelling language SystemC.	
Modes of teaching and learning	The module includes 2 hours per week lectures and 2 hours per week exercises as well as self-study.	
Prerequisites	Programming knowledge in C/C++ as well as basic knowledge and skills in technical computer science are required, in particular the participants should be familiar with the basics at Bachelor level.	
Usability	The module is an elective module in the Nanoelectronic Systems Master's program.	
Requirements for the award of credit points	The credit points are earned when the module examination has been passed. For up to 10 registered participants, the module examination consists of an oral examination performance as an individual examination lasting 20 minutes. If there are more than 10 participants, the examination consists of a written examination lasting 60 minutes. The type of concrete examination will be determined by the module supervisor at the end of the examination registration period and will be publicly announced in accordance with faculty practice.	
Credit points and grades	6 credit points can be earned through the module. The module grade corresponds to the grade of the examination performance.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 180 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 10 04-14.1	Hardware/Software Codesign Lab	Dr. Emil Matúš
Contents and objectives	Content of the module: Approaches to accelerate digital signal processing algorithms Outcomes: The students know the ASIP design methodology (Application Specific Instruction Processor). They can independently implement algorithms and are able to participate with their own contributions to discussions about the complexity, memory usage, layout of data in the memory architecture and possible improvements.	
Modes of teaching and learning	The module consists of 2 hours per week practical training and self-study.	
Prerequisites	Knowledge in Hardware/Software Codesign, as e.g. are taught in the module Hardware/Software Codesign, and basic knowledge in assembly language programming, Matlab and DSP architecture concepts on bachelor level.	
Usability	The module is a required elective module in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a project report in the scope of 30 hours.	
Credit points and grades	4 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 120 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-ET-22-E-ICAND	Innovative Concepts for Active Nanoelectronic Devices	Prof. Dr.-Ing. T. Mikolajick
Contents and objectives	The module includes innovative semiconductor components and nanoelectronic materials. Objectives: The students will have the ability, to recognize material science boundary conditions with the help of knowing the design, properties, production and structure formation of materials and the effects and the basic types of small structures of component concepts, applications and future trends as well as the bottom up and top down nanoelectronic concepts. Furthermore, they will be able to design innovative concepts for active components and systems of nanoelectronics and to understand physical effects and transport mechanisms, as well as to recognize concrete embodiments for components currently in use but also in the research or development stage and the respective technological and electrical boundary conditions.	
Modes of teaching and learning	4 hours per week lectures, 2 hours per week tutorials, and self-study. The module is taught in English.	
Prerequisites	Competencies in basic physics, semiconductor electronics, and electronic devices are required.	
Requirements for the award of ECTS credit points	The credit points are earned if the module assessment is passed. If the number of registered students exceeds 20, the module assessment consists of 2 written exams of 90 minutes each and a collection of practical lab course tests. With up to 20 registered students the assessment consists of 2 individual oral exams of 20 minutes each.	
ECTS credit points and grades	7 ECTS credit points The grade of the module is the weighted mean of the different elements of assessment: M = (4PL1+ 4PL2 + 2PL3)/10.	
Frequency	annually, in the winter semester	
Workload	210 hours	
Duration	1 semester	

Module number	Module name	Lecturer in charge
NES-12 08 04-14.1	Integrated Circuits for Broadband Optical Communications	Prof. Ellinger
Contents and objectives	The module content includes: - Design of integrated circuits in aggressively scaled nanotechnologies, focusing on the broadband optical communications - Transimpedance amplifier, detector circuits, laser drivers, multiplexers, frequency dividers, oscillators, phase locked loops, synthesizers and data recovery circuits - Challenges (eg, high bandwidth, gain, noise and good large signal performances despite of lower voltages) and appropriate solutions for circuits in nanotechnology Qualication goals: Students obtain competences regarding - methods for the design of very fast integrated circuits and systems for optical communications, - the analysis and optimisation of these circuits, and - The students get to know design tools for circuits - The students use the English technical language in the field of high-frequency circuits.	
Modes of teaching and learning	The module consists of 3 hours per week lectures, 1 hour per week tutorials, 2 hours per week practical training and self-study.	
Prerequisites	Basic knowledge in analog circuit design on bachelor level is required.	
Usability	The module is a required elective module in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 120 minutes. The exam can be written either in German or Englisch.	
Credit points and grades	7 credit points can be obtained by the module. The module grade is the grade of the written exam.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 210 hours.	
Duration	The module takes one semester.	

Module number	**Module name**	**Lecturer in charge**
NES-12 10 06-14.1	Integrated Photonic Devices for Communications and Signal Processing	Prof. Jamshidi
Contents and objectives	After the completion of the module the students know theoretical background and technologies of various integrated photonic devices on silicon, with the emphasis on communications and signal processing. They can model, design, and simulate basic components including passive devices (waveguides, couplers, Gratings, Interferometers, resonators, filters) as well as high speed electro-optical modulators (Mach Zehnder and micro ring), electro-absorption modulators, high speed photo diodes, and lasers. They are able to analyze and synthesize these devices using different analytical and numerical methods. Students can communicate in English.	
Modes of teaching and learning	The module consists of 4 hours per week lectures and 2 hours per week practical training and self-study. The language of instruction is English at least partly.	
Prerequisites	Knowledge on bachelor Niveau of Electromagnetism and Semiconductors	
Usability	The module is a required elective module of the branch of study Nanoelectronics in the Master's program of Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of an assigned paper in scope of 30 hours and an oral exam as individual exam worth 30 minutes.	
Credit points and grades	7 credit points can be earned by the module. The module grade is the unweighted mean of the grades for the assigned paper and the oral exam.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 210 hours.	
Duration	The module takes one semester.	
Accompanied Literature	G. T. Reed, Silicon Photonics: The State of the Art (Wiley, 2008). A. Yariv and P. Yeh, Photonics, 6th ed (Oxford, 2007).	

Module number	Module name	Lecturer in charge
NES-12 10 08	Introduction to Optical Non-classical Computing: Concepts and Devices	Prof. Jamshidi
Contents and objectives	After the completion of the module the students know various optical computing methods. They know the basic principles of artificial neural networks, quantum computation, and Ising machines. Also, students know both linear and nonlinear photonic devices which are needed for the realization of these methods. Students can communicate in English	
Modes of teaching and learning	The module consists of 4 hours per week lectures and 2 hours per week practical training and self-study. The language of instruction is English	
Prerequisites	Knowledge on Bachelor Niveau of Electromagnetism, System theory, and Semiconductors.	
Usability	The module is an elective module for the Master's program of Nano-electronic Systems	
Requirement for the award of credit points	The credit points are awarded if the module examination is passed.The credit points are awarded when the module assessment is passed. The module assessment consists of an assigned paper in the scope of 30 hours and an oral exam as individual exam worth 30 minutes.	
Credit points and grades	7 credit points can be earned by the module. The module grade is the unweighted average of the grade of the assigned paper and the grade of the oral exam M = (PL1 + PL2) / 2.	
Frequency	The module is offered every summer semester.	
Workload	The total effort is 210 hours.	
Duration	The module takes one semester	
Accompanied Literature	1. Quantum Computations and Quantum Information by M. Nielsen and I. L. Chuang 2. Adiabatic Quantum Computation and Quantum Annealing: Theory and Practice by C. C. McGeoch 3. Principles of Artificial Neural Networks by D. Graupe Other materials presented in the class	

Modul number	Module name	Lecturer in charge
NES-E-JCAS	Joint Communications and Sensing Systems for 6G Networks	Prof. Dr.-Ing. Dr. h.c. Gerhard Fettweis gerhard.fettweis@tu-dresden.de
Objectives	Upon successful completion of the module, students will acquire a comprehensive understanding of joint communications and sensing technology at the system level. They will possess the ability to interpret the implications of key theorems and analyze how the final equations interpret the operations and characteristics of JCAS. Furthermore, the module aims to furnish students with an overview of the current state of the art in JCAS. By gaining a strong foundation in the fundamental principles, technologies, and applications of JCAS, students will be sufficiently equipped to actively contribute to the progress and implementation of JCAS solutions across various scenarios.	
Contents	The module provides an in-depth exploration of the core ideas, principles, and technologies underlying communication systems and sensing technologies, both crucial components of the future generation networks. It highlights the interconnection of these fields and their collaborative role in improving and enabling simultaneous operations. The module begins by introducing the waveforms employed in JCAS, followed by a brief review of estimation and detection theories that form the foundation of both sensing and communications. It proceeds to investigate multiple antenna-JCAS, followed by the unique characteristics of the mmWave frequency band, and their impact on JCAS system design. The module then delves into the analysis of communication-centric, radar-centric, and dual-centric waveforms for JCAS. Ultimately, the module covers the application of optimization and information theories to facilitate the design of JCAS waveforms.	
Modes of teaching and learning	2 hours per week lectures, 2 hours per week exercises, and self-study	
Prerequisites	A basic understanding of Electrical Engineering or Computer Science, along with basic knowledge of mathematics at the Bachelor's level, is necessary.	
Usability	The module is an elective module in the Master’s program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam of 90 minutes.	
Credit points and grades	5 credit points can be obtained by the module. The module grade is the grade of the examination.	

Frequency	The module is offered every winter semester.
Workload	The total effort is 150 hours.
Duration	The module takes one semester.

Module number	Module name	Lecturer in charge
INF-DSE-20-E-EHS-L	Lab Embedded Hardware Systems Design	Prof. Dr. Akash Kumar akash.kumar@tu-dresden.de
Objectives	After completion of the module students can practically translate system specifications into executable calculation models using a high specification language and decode these formal specifications into a register-transfer-level HDL.	
Contents	The module focuses on hands-on practice of developing complex embedded systems. This includes the application of methods for the development of embedded systems, the concrete specification and modeling of selected problems, the practical decoding of specifications in architectures and the rapid construction of a prototype on FPGA platforms.	
Modes of teaching and learning	2 hours per week practical training, and self-study	
Prerequisites	There are competences required that can be purchased for example in the module Embedded Hardware Systems Design.	
Usability	The module is an elective module in the Master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a project work of 90 hours.	
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 180 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-12 06 01-14.1	Materials for the 3D System Integration	Prof. Dr.-Ing. Dr. h.c. K. Bock
Contents and objectives	The module consists of content 1. 3D system integration and 3D technologies – Introduction: 3D/2.5D concepts and Si interposer – Fabrication of the Through Silicon Vias (TSVs) – Cu-Plating for TSV, Redistribution Layer (RDL) and Bumping – Si Wafer Thinning – Si Wafer Bonding und Stacking 2. Micro-/Nanomaterials and reliability aspects – Scaling of the interconnects and new challenges – Materials for interconnects (phase diagrams, microstructure, mechanical/thermo-mechanical behavior, reliability) – Nanomaterials for the 3D system integration (nanocomposites, functional layers, nanoporous materials, etc.) – Reliability prognosis for new interconnect systems Qualification goals: The students know the technologies for the fabrication of miniaturized 3D and 2.5D components as well as Si interposer with TSVs. They can select the materials for the 3D packages with a respect of their impact on reliability. Students are familiar with new concepts in nanomaterials application for 3D packages. The students can communicate in English.	
Modes of teaching and learning	The module consists of 4 hours per week lectures, 1 hour per week labs, one excursion and self-study. The language of instruction is English at least partly.	
Prerequisites	There are competences required, that can be purchased for example at the modules *Semiconductor Technology (first semester) and Materials for Nanoelectronics and Vacuum Technology.* The basic knowledge in the area of Electronics Packaging Technology is welcome.	
Usability	The module is a required elective module of the branch of study Nanoelectronics in the master’s program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of two written exams in the amount of 90 minutes for each and an ungraded lab course. The lab course must be passed.	
Credit points and grades	7 credit points can be earned by the module. The module grade is the unweighted mean of the grades of the two written exams.	
Frequency	The module is offered every academic year beginning in the summer semester.	

Workload	The total effort is 210 hours.
Duration	The module takes two semesters.

Module number	Module name	Lecturer in charge
NES-12 12 03-14.1	Memory Technology	Prof. Dr.-Ing. T. Mikolajick
Contents and objectives	This module covers memory concepts in the market and in research respectively development stage: - Magnatic memories - Optival memories - Semiconductor memories (SRAM, DRAM, nonvolatile Memories (EPROM, EEPROM, Flash)) - Innovative semiconductor memories (e.g. ferroelectric, magnetoresistive, resisitive, organic, and single molecule memories) Qualification goals: After completion of the module the students have the comeptences to optimize and develop new generetions of existing memory concepts. Based on the physical effects they will also be able to devolpe new memory concepts. Furthermore the students are able to evaluate areas of application for the memory concept and are aware of their limitation.	
Modes of teaching and learning	The module consists of 4 hours per week lectures, 2 hours per week seminars and self-study.	
Prerequisites	Requirements are necessary , which can be obtained in the first part of module Semiconductor Technology and in the module Materials for Nanoelectronics and Vacuum Technology for example.	
Usability	The module is a required elective module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems and a required elective module in the main study of the degree program Elektrotechnik.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consist of a written exam in the amount of 90 minutes, if the number of registered students exceeds 20. With up to 20 registered students the witten exam will be replace by an oral exam as an individual exam worth 15 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty.	
Credit points and grades	7 credit points can be obtained by the module. The module grade is the grade of the module assessment.	
Frequency	The module is offered every academic year beginning in the summer semester.	
Workload	The total effort is 210 hours.	
Duration	The module takes two semester.	

Module number	Module name	Lecturer in charge
NES-13 14 02-14.1	Molecular Electronics	Prof. Cuniberti
Contents and objectives	The students know the basics of molecular electronics with emphasis on: experimental methods, physical effects and theoretical tools, such as single molecule electronics, raster probe and break-junction techniques, transport mechanisms at the nanoscale, molecular components (diodes, transistors, sensors) and molecular architectures. The students know the most important experimental and theoretical methods of investigation of charge transport at the molecular scale.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours per week tutorials and self-study.	
Prerequisites		
Usability	The module is a required elective module in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consits of a written exam in the amount of 90 minutes, if the number of registered students exceeds 10. With up to 10 registered students the written exam will be replaced by an oral exam as individual exam worth 20 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty.	
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 180 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-13 14 01-14.1	Nanotechnology and Material Science	Prof. Cuniberti
Contents and objectives	After completing the module the students know the basic physics of nanotechnology and the production and properties of nanostructured materials, including - quantum effects, mesoscopic systems, scaling laws - fabrication of clusters and nanotubes - band structure, density of states, electron transport in low-dimensional solids - theoretical foundations of scanning tunneling microscopy, atomic force microscopy, and optical near-field microscopy - nanostructuring via electron beam lithography, optical lithography, and scanning probe methods - Giant magnetoresistance, single electronic devices	
Modes of teaching and learning	The module consists of 4 hours per week lectures, 2 hours per week tutorials, 2 hours per week practical training and self-study.	
Prerequisites	The basics of physics, chemistry, and quantum mechanics	
Usability	The module is a required elective module of the branch of study nanoelectronics in the master’s program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 90 minutes, an oral exam as an individual exam worth 20 minutes and a graded lab course record, if the number of registered students exceeds 10. With up to 10 registered students the written exam is replaced by an oral exam as individual exam worth 20 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty.	
Credit points and grades	12 credit points can be obtained by the module. The module grade is the unweighted mean of the grades of the exams.	
Frequency	The module is offered every summer semester.	
Workload	The total effort is 360 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturers in charge
NES-22-E-NNMHA	Neural Networks and Memristive Hardware Accelerators	Prof. Dr. phil. nat. habil. Ronald Tetzlaff (ronald.tetzlaff@tu-dresden.de)
Objectives	After completion of the module, students are familiar with the concepts of machine learning and neural networks. They understand that these neural learning methods rely on large amounts of data and that computational power is a limiting factor in developing neural models. Students will be familiar with basic neural network accelerators for synapses and neurons specifically based on memristors and understand the main circuit theories for modeling memristors and their applications like logic circuits, crossbar arrays, and spiking neural networks. In addition, students have competencies in Python programming, implementing basic neural models in code using ML-related Python libraries such as PyTorch, and are able to implement and simulate memristors using LTSpice.	
Content	Contents of the module are basic concepts of machine learning and neural networks for different types of data such as time series and images as well as different neural learning methods, optimizers and loss functions. Furthermore, principles of neural network accelerators for synapses and neurons based on memristors are covered, as well as circuit theory and models and applications of memristors, such as logic circuits, crossbar arrays, and spiking neural networks. The module covers essential Python programming concepts related to the above topics.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours per week semester project with tutorials, as well as 2 hours per week practical programming and self-study.	
Prerequisites	Basic knowledge in the areas of electrical engineering and programming languages on bachelor level is required.	
Usability	The module is an elective module in the master's program, Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module exam consists of an oral exam of 15 minutes duration as an individual exam, and a presentation. If there are more than 15 registered students, the oral examination can be replaced by an exam of 180 minutes. The type of examination will be announced to the registered students at the end of the registration period, as is customary for the faculty.	
Credit points and grades	7 credit points can be obtained by the module. The module grade is based on the weighted average of the grades of the two examinations. The oral exam or written exam is weighted four times and the presentation is weighted simply.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 210 hours.	

Duration	The module takes one semester.

Modul number	Module Name	Lecturer in Charge
NES-12 08 06	Neuromorphic VLSI Systems	Prof. Dr.-Ing. habil. C. Mayr

Contents and objectives	Content of the module: - Methods for design and sizing of integrated analogue CMOS circuits - Neuromorphic VLSI systems: neurobiological fundamentals, common abstraction models, and application in science and technology, e.g. in brain machine interfaces and for signal processing - Fundamentals, concepts and methods of design and analysis of analouge and neuromorphic CMOS circuits using the design framework Cadence DF2 The module consists of lectures on fundamentals of neuromorphic systems and on CMOS circuit design, as well as accompanying computer exercises using the corresponding VLSI design tools. Objectives: After completing the module, students are literate in the field of neural networks from neurobiological principles up to applications. They are able to use industrial design tools (Cadence DF2, Spectre), to design and size CMOS circuits, to verify parameters and constraints by simulation and to design circuit layouts.
Modes of teaching and learning	4 hours per week lectures, 2 hours per week exercises, and self-study
Prerequisites	
Usability	The module is an elective module in the master's program Nanoelectronic Systems.
Requirements for the award of credit points	Credit points are awarded on passed module assessments. The module assessment consists of an assignment paper and a presentation.
Credit points and grades	7 credit points can be obtained by the module. The module grade is the weighted mean of the grades from the assignment paper weighted by 2/3 and the grade of the presentation weighted by 1/3.
Frequency	The module is offered every summer semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.

Module number	Module name	Lecturer in charge
NES-12 12 05-14.1	Optoelectronics	Prof. Lakner
Contents and objectives	Contents: Nano-Optics: - Optical phenomena on the length scale much lower than the diffraction limit of the wavelength λ, e.g. interaction between fluorescent atoms and molecules, optical interaction between molecules and surfaces, but also surface-reinforcing effects. - Usage of nano-optics for novel devices and applications (analysis and characterization). Opto-Electronic Devices and Systems: The principles and technical realization of optoelectronic devices and systems (such as light emitting diodes, laser diodes, compound semiconductors, organic semiconductors, micro-opto-electro-mechanical systems for modulation and deflection of light) and applications of these devices in projection systems, displays, modulators and optical storage. Outcomes: The students know the most important optical phenomena on length scales far below the diffraction limit (etc. bright and non-brihht recombination processes, electric field enhancement at interfaces and surfaces) and understand their application in optical devices and their use in applications. They know how optoelectronic components and systems are implemented and how they are used in applications (e.g. projection systems, displays).	
Modes of teaching and learning	The module consists of 4 hours per week lectures, 1 hour per week tutorials and self-study.	
Prerequisites	Basic knowledge about technical optic on bachelor level	
Usability	The module is a required elective module in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of an oral exam as individual exam worth 20 minutes and a written exam in the amount of 60 minutes, if the number of registered students exceeds 20. With up to 20 registered students the written exam is replaced by an oral exam as individual exam worth 20 minutes. The nature of the specific exam is announced at the end of the registration period as usually known from the faculty.	
Credit points and grades	7 credit points can be obtained by the module. The module grade is unweighted mean of the grades of the examinations.	
Frequency	The module is offered every winter semester.	

Workload	The total effort is 210 hours.
Duration	The module takes one semester.
Accompanied Literature	1. Bergmann, Schäfer, Niedrig (Hg): Lehrbuch der Experimentalphysik. Band III Optik. Walter de Gruyter Verlag Berlin, New York 2004 2. L. Novotny, B. Hecht: Principles of NanoOptics, Cambridge University Press (2006)

Module number	**Module name**	**Lecturer in charge**
NES-E-PD-23	Physical Design	Dr. Padmanava Sen, Dr.-Ing. Sebastian Haas
Objectives	After completing this module, students master the basic principles and practical application of digital circuit design (physical design) of a system-on-chip. Physical design is an integral part of development of digital hardware. The content taught in this course will help the students to plan and execute implementations of systems like processors, advanced VLSI systems design and physical layers of communications. The objectives of this course can be summarized below: • Understand the background in CMOS and devices, representing them in behavioral, structural, and physical domain and how it differs from an analog circuit implementation • Understand the concepts of Physical Design Process such as partitioning, floor planning, placement and routing • Get an introduction to the concepts of design optimization algorithms and their application to Physical Design Automation • Understand the concepts of simulation and synthesis in VLSI Design Automation (using standard cells, FPGAs, etc.) • Be able to formulate challenges in a realistic IC design and figure out the steps to solve/mitigate them • Understand how the CAD tools work to facilitate the IC design (in a nutshell)	
Contents	The course contents are given below: • Digital design and standard cells (different technologies) • Netlisting and system portioning • Floorplanning • Routing and placement (block level, chip level) • Timing analysis and performance constraints • Clock tree analysis and signal integrity • DRC related to physical synthesis • Parasitic extraction Apart from providing backgrounds, the course offers a hands-on training to practice the acquired theoretical knowledge. This includes access to the tools used for physical design and to design a small digital chip.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 1 hour per week practical training and self-study.	
Prerequisites	Participants should have knowledge of digital electronic circuits and microprocessor architectures. Basic Verilog/VHDL programming knowledge will be needed to follow the practical part of the course.	
Usability	The module is an elective module in the Master's program Nanoelectronic Systems.	

Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written report including research study and documentation of the practical work and a presentation of 15 minutes duration.
Credit points and grades	6 credit points can be obtained by the module. The module grade is the weighted mean of the grade from the report weighted by 2/3 and the grade of the presentation weighted by 1/3.
Frequency	The module is offered every summer semester.
Workload	The total effort is 180 hours.
Duration	The module takes one semester.

Module number	Module name	Lecturer in charge
NES-ET-E-PlaTe	Plasma Technology	Prof. Dr. rer. nat. habil. Elizabeth von Hauff elizabeth.von_hauff@tu-dresden.de
Objectives	After completion of the module students have a fundamental understanding of the physics of plasmas used in industrial processes and tools. Furthermore, they are able to choose suitable technical plasma sources and plasma process tools for specific applications. In addition they can name typical examples for layers and layer stacks used in major application fields for coatings.	
Contents	The module focuses on the fundamentals of plasma physics, industrial plasma processes, and process tool design as well as the basics of thin film growth, hard coatings and barriers, glass and optical coatings, electronic and functional coatings, and treatment technologies.	
Modes of teaching and learning	4 hours per week lectures, 2 hours per week exercises, and self-study	
Prerequisites	Basic knowledge of Microelectronic Technologies and Devices on Bachelor level is recommended.	
Usability	The module is an elective module in the Master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam of 90 minutes.	
Credit points and grades	7 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 210 hours.	
Duration	The module takes one semester.	

Module Number	Module Name	Lecturer in Charge
NES-02 04 01	Quantum Mechanics for Nanoelectronics	Prof. Dr. M. Helm
Contents and objectives	The module deals with basic quantum mechanics with applications to solid state physics and nanoelectronics. The foundations will be laid for a microscopic understanding of electronic materials and devices. The students know basic quantum mechanics and its application to periodic solids. They know the treatment of the hydrogen atom and time-dependent perturbation theory. In particular, they can apply the Schrödinger equation to one-dimensional problems independently. They know about semiconductor nanostructures (two, one, and zero-dimensional structures, i.e., quantum wells, wires, and dots), their fabrication and their energy levels, electron transport and optical absorption, their application to devices, as well as the effect of a magnetic field.	
Modes of teaching and learning	The module consists of 5 hours per week lectures and 1 hour per week exercises.	
Prerequisites	Knowledge of basic physics at bachelor level.	
Usability	The module is a required elective module in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded, when the module assessment has been passed. The module assessment consists of an individual, oral exam of 30 minutes duration.	
Credit points and grades	7 credit points can be earned by the module. The module grade is the grade of the oral exam.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 210 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-E-LSer-23	Requirements and methodologies for design of integrated circuits from industrial production perspective	Prof. Dr. Stefan E. Schulz stefan.schulz@zfm.tu-chemnitz.de
Objectives	After completion of the module, the students have a deeper understanding of the requirements for the industrial design of integrated circuits and of the design methods used in circuit design.	
Contents	The module focuses on various aspects of integrated circuit design from an industrial manufacturing perspective. It includes an overview of the design requirements throughout the creation and lifetime of integrated circuits: from first idea, system and circuits design phase via prototype evaluation and test development to ramp-up and application support. Also the special needs of automotive integrated circuits will be investigated, like thorough methodologies for verification, reliability and functional safety. The lectures will be held by various experts from the local semiconductor industry and research.	
Modes of teaching and learning	4 hours per week lectures, and self-study	
Prerequisites	Basic knowledge of the design of analogue and digital circuits and systems on Bachelor level is recommended.	
Usability	The module is an elective module in the Master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam of 90 minutes.	
Credit points and grades	5 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every summer semester.	
Workload	The total effort is 150 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-E-ResM-23	Resource Management	Prof. Dr. Edeltraud Günther edeltraud.guenther@tu-dresden.de
Objectives	After completion of the module, students are able to identify and independently analyze entrepreneurial resources, especially in relation to the natural environment. In addition, students are able to independently solve problems in groups and present their proposed solutions in writing.	
Contents	The module focuses on environmental resources in order to evaluate them with regard to environmentally relevant aspects and integrate them into business decisions. As part of the module, students deal with the following questions: Which instruments exist for environmental assessment and decision-making in a company? How can ecologically-oriented corporate strategies be used to increase corporate values? How can environmental management systems be used for adequate resource management?	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours per week project and self-study. The language of instruction can be German or English and is specified by the lecturer at the beginning of each semester and announced in the usual way at the faculty.	
Prerequisites	Literature: - Stechemesser, K., & Guenther, E. (2012). Carbon accounting: a systematic literature review. *Journal of Cleaner Production*, 36(Supplement C), 17–38. - Steffen, W., *et al.* (2015). Planetary boundaries: Guiding human development on a changing planet. *Science,* 347(6223), 1259855. - Whiteman, G., Walker, B., & Perego, P. (2013). Planetary boundaries: ecological foundations for corporate sustainability. *Journal of Management Studies*, 50(2), 307-336.	
Usability	The module is an elective module in the Master's program Nanoelectronic Systems of which at least 39 credit points must be selected in the branch of study Nanoelectronics and at least 15 credit points in the branch of study Nanoscience and Nanotechnology.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a project work in the amount of 90 hours.	
Credit points and grades	5 credit points can be obtained by the module. The module grade is the grade of the examination.	

Frequency	The module is offered at irregular intervals, usually once during the academic year.
Workload	The total workload is 150 hours.
Duration	The module takes one semester.

Module number	Module name	Lecturer in charge
NES-12 09 01-14.1	Stochastic Signals and Systems	Prof. Jorswieck
Contents and objectives	After completion of the module the students master the description methods of stochastic signals as realizations of stochastic processes. They are in a position to calculate the behavior of deterministic and stochastic systems under the condition that the systems handle stochastic processes.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours of tutorials per week, and self-study.	
Prerequisites	Basics of the theory of deterministic systems and basic knowledge of probability calculus on bachelor level	
Usability	The module is a required elective module of the branch of study Nanoelectronics in the master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment is a written exam in the amount of 90 minutes.	
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 180 hours.	
Duration	The module takes one semester.	

Module number	Module name	Lecturer in charge
NES-11 06 07-14.1	Ubiquitous Systems	Chair of Distributed and Networked Systems netd-teaching@tu-dresden.de
Contents and objectives	After completion of the module, the students will be able to analyse the requirements needed by distributed applications and also in the context of mobile networks. They can evaluate existing solutions and put them into practice based on a reasonable conceptional foundation. The module provides knowledge of the problems, concepts and possible solutions regarding the development of distributed systems. The focus will be on essential fundamental principles and basic techniques as well as latest standards. Furthermore, the students will learn the basics of mobile communication and its application in the field of mobile computing. Besides transmission basics of wireless networks, typical standards and network concepts, the module also deals with software architectures for mobile computing and distributed systems in the field of application support. In addition, the module gives an outlook on future high performance mobile networks and its applications.	
Modes of teaching and learning	The module consists of 4 hours per week lectures, 2 hours per week tutorials and self-study.	
Prerequisites	Students should have basic knowledge of the areas of computer networks and operating systems on Bachelor level.	
Usability	The module is a required elective module in the Master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amont of 120 minutes.	
Credit points and grades	7 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every winter semester.	
Workload	The total effort is 210 hours.	
Duration	The module takes one semester.	
Accompanied Literature	Tanenbaum, A.S.: Computer Networks.	

Modul Number	Modul Name	Lecturer in Charge
NES-12 08 07	VLSI Processor Design	Prof. Mayr

Contents and objectives	Content of the module: • Basics, concepts and methods for designing complex digital VLSI-systems • Architectures for highly integrated digital processing systems, with emphasis on user-specific signal processing systems • Methods for the efficient transfer of architectural concepts in the highly integrated implementation of a digital system. • Specification and abstract modelling of the system, conversion into a Register-Transfer-Level (RTL) description, automated circuit synthesis and physical implementation (place & route, layout synthesis), which results in the data needed for manufacture of the chip. • Verification of the design on all levels of abstraction (behaviour, implementation) via simulation (functional verification) • Proof of the equivalence of transformation steps via formal verification, i.e. by checking compliance with design rules (signoff-verification) • Training in working together as a design team (division of tasks, definition of interfaces, schedule planning and time management) Objectives: After completion of this module, the students will be able to carry out a complete implementation and verification of a VLSI-System (e. g. a processor with a complexity comparable to an 8051) using industrial design software (Synopsys, Cadence).
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours tutorial, 2 hours lab work and self-study.
Prerequisites	
Usability	The module is an elective module in the master's program, Nanoelectronic Systems.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a project report with a scope of 30 hours and a presentation of 20 minutes duration.
Credit points and grades	7 credit points can be obtained by the module. The module grade is the weighted mean of the grades of the project weighted by 2/3 and the grade of the presentation weighted by 1/3.
Frequency	The module is offered every summer semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.

Module number	Module name	Lecturer in charge
NES-11 06 04-14.1	Wireless Sensor Networks	Dr.-Ing. habil. Dargie
Contents and objectives	After completion of the module, the students have a qualified understanding of wireless sensors, the networks designed with them, their architecture, the protocols and the common applications. They are able to evaluate existing networks and to design new ones. The content of the module focuses on self-management algorithms, media access methods, routing algorithms, localization technologies and data management tools for wireless sensor networks.	
Modes of teaching and learning	The module consists of 2 hours per week lectures, 2 hours per week seminars and self-study.	
Prerequisites	Students should have basic knowledge of computer architecture, distributed systems, mobile communication, and software engineering on Bachelor level.	
Usability	The module is a required elective module in the Master's program Nanoelectronic Systems.	
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a written exam in the amount of 60 minutes.	
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the examination.	
Frequency	The module is offered every summer semester.	
Workload	The total effort is 180 hours.	
Duration	The module takes one semester.	

Appendix 2 Curriculum Plans

A-2.1. Curriculum plan for full-time students in the branch of study Nanoelectronics

with type and number of SWS (= class hours per week per semester) and the necessary assessments, the type, hours and organisation of which are described in the module descriptions

A-2.1.1 Overview of required modules

module no.	module name	1st semester	2nd semester	3rd semester	4th semester	CP
		V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	
NES-11 06 01-19.1	Lab Sessions	0/0/0/0/2 PVL PL	0/0/0/0/1 PL			5
NES-11 06 02-14.1	Principles of Dependable Systems	2/2/0/0/0 PVL PL				6
NES-12 10 01-14.1	Fundamentals of Estimation and Detection	2/2/0/0/0 PL				6
NES-12 12 02-19.1	Semiconductor Technology	4/0/0/0/0	2/0/0/0/0 PL			9
NES-12 08 02-14.1	Radio Frequency Integrated Circuits		3/1/0/0/2 PL			7
NES-12 10 03-14.1	Hardware/Software Codesign		2/1/0/0/0 PL			4
NES-12 ASW-14.1	Academic and Scientific Work			*/*/*/*/* *		4
NES-12 PW-14.1	Project Work			project PL		10
	required elective modules, see following pages	6 CP	17 CP	16 CP		39
					master thesis	29
					defence	1
		30	**30**	**30**	**30**	**120**

V lecture
Ü tutorial
Se seminar
Sp language course
P lab course

PL assessment(s)
PVL pre-exam achievement(s)
CP credit points
* in acc. with student’s choice

A-2.1.2 Required elective modules

module no.	module name	1st semester	2nd semester	3rd semester	CP
		V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	
NES-INF-DSE-20-M-SE1	Foundations of Systems Engineering	2/2/0/0/0 PVL PL			5
NES-30 GLC-14.1	German Language and Culture	0/0/0/4/0 PL			4
NES-E-JCAS	Joint Communications and Sensing Systems for 6G Networks	2/2/0/0/0 PL			5
NES-22-E-NNMHA	Neural Networks and Memristive Hardware Acceleratos	2/0/0/0/2 2xPL 2 projects			7
NES-12 09 01-14.1	Stochastic Signals and Systems	2/2/0/0/0 PL			6
NES-E-ACSR	Adaptive Computing Systems for Robotics		2/2/0/0/0 PL		6
NES-E-AdLsy	Adaptive Laser Systems		2/1/0/0/1 2xPL		5
NES-12 10 05-20.1	Antennas and Radar Systems		4/2/0/0/0 PL		7
NES-E-AJCAS	Applied Joint Communications and Sensing Systems		2/0/0/0/2 PL		5
NES-12 10 02-14.1	Communications		2/1/0/0/0 PL		3
NES-E-DNNH-23	Deep Neural Network Hardware		2/2/0/0/0 PL		5
NES-11 20 19	Design and Programming of Embedded Multicore Architectures		2/2/0/0/0 PL		6
NES-INF-DSE-20-E-SFT	Foundations of Software-Fault Tolerance		2/2/0/0/0 PL		6
NES-12 10 08	Introduction to Optical Non-classical Computing: Concepts and Devices		4/2/0/0/0 2xPL		7
NES-13 14 01-14.1	Nanotechnology and Materials Science		4/2/0/0/2 3xPL		12
NES-12 08 06	Neuromorphic VLSI Systems		4/2/0/0/0 2xPL		7
NES-E-PD-23	Physical Design		2/0/0/0/1 2xPL		6

module no.	module name	1st semester	2nd semester	3rd semester	CP
		V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	
NES-E-LSer-23	Requirements and methodologies for design of integrated circuits from industrial production perspective		4/0/0/0/0 PL		5
NES-E-ResM-23	Resource Management		2/0/0/0/0 2 Projekt PL		5
NES-12 08 07	VLSI Processor Design		2/2/0/0/2 2xPL		7
NES-11 06 04-14.1	Wireless Sensor Networks		2/0/2/0/0 PL		6
NES-12 06 01-14.1	Materials for the 3D System Integration		2/0/0/0/0 PL	2/0/0/0/1 2xPL	7
NES-12 12 03-14.1	Memory Technology		2/0/1/0/0	2/0/1/0/0 PL	7
NES-12 10 20	Communication Networks 3			4/2/0/0/0 PL	7
NES-ET-E-ComLS-23	Computational Laser Systems			3/1/0/0/0 PL	5
NES-12 12 04-14.1	Electromechanical Networks			2/1/0/0/0 PL	4
NES-INF-E-FCPL	Foundations of Certified Programming Language and Compiler Design			2/2/0/0/0 PL	6
NES-12 08 01-20.1	Future Computing Strategies in Nanoelectronic Systems			2/1/0/0/0 PL	4
NES-11 20 20	Hardware Modelling and Simulation			2/2/0/0/0 PL	6
NES-12 10 04-14.1	Hardware/Software Codesign Lab			0/0/0/0/2 PL	4
NES-ET-22-E-ICAND	Innovative Concepts for Active Nanoelectronic Devices			4/1/0/0/1 3xPL	7
NES-12 08 04-14.1	Integrated Circuits for Broadband Optical Communications			3/1/0/0/2 PL	7
NES-12 10 06-14.1	Integrated Photonic Devices for Communications and Signal Processing			4/0/0/0/2 2xPL	7

module no.	module name	1st semester	2nd semester	3rd semester	CP
		V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	
NES-E-JCAS	Joint Communications and Sensing Systems for 6G Networks			2/2/0/0/0 PL	5
NES-13 14 02-14.1	Molecular Electronics			2/2/0/0/0 PL	6
NES-12 12 05-14.1	Optoelectronics			4/1/0/0/0 2xPL	7
NES-ET-E-PlaTe	Plasma Technology			4/2/0/0/0 PL	7
NES-02 04 01	Quantum Mechanics for Nanoelectronics			5/1/0/0/0 PL	7
NES-11 06 07-14.1	Ubiquitous Systems			4/2/0/0/0 PL	7

A-2.2 Curriculum plan for full-time students in the branch of study Nanoscience and Nanotechnology

with type and number of SWS (= class hours per week per semester) and the necessary assessments, the type, hours and organisation of which are described in the module descriptions

A-2.2.1 Overview of required modules

module no.	module name	1st semester	2nd semester	3rd semester	4th semester	CP
		V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	
		°	°	°	°	60
NES-12 ASW-14.1	Academic and Scientific Work			*/*/*/*/* *		4
NES-12 PW-14.1	Project Work			project PL		10
	required elective modules, see following pages			16 CP		16
					master thesis	29
					defence	1
		30	**30**	**30**	**30**	**120**

V lecture
Ü tutorial
Se seminar
Sp language course
P lab course
PL assessment(s)
PVL pre-exam achievement(s)
CP credit points
° Academic achievements and assessments of the degree program Nanoscience and Nanotechnology at KU Leuven (Belgium) according to a cooperation agreement
* according to choice of student

A-2.2.2 Required elective modules

module no.	module name	1st semester	2nd semester	3rd semester	LP
		V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	V/Ü/Se/Sp/P	
NES-INF-DSE-20-M-SE1	Foundations of Systems Engineering	KU LEUVEN		2/2/0/0/0 PVL PL	5
NES-12 12 04-14.1	Electromechanical Networks			2/1/0/0/0 PL	4
NES-12 08 01-20.1	Future Computing Strategies in Nanoelectronic Systems			2/1/0/0/0 PL	4
NES-30 GLC-14.1	German Language and Culture			0/0/0/4/0 PL	4
NES-12 10 04-14.1	Hardware/Software Codesign Lab			0/0/0/0/2 PL	4
NES-12 12 07-14.1	Innovative Semiconductor Devices			2/1/0/0/0 PL not offered	4
NES-12 08 04-14.1	Integrated Circuits for Broadband Optical Communications			3/1/0/0/2 PL	7
NES-12 10 08	Introduction to Optical Non-classical Computing: Concepts and Devices			4/2/0/0/0 2xPL not offered in winter semester	7
NES-12 12 01-14.1	Materials for Nanoelectronics and Vacuum Technology			4/0/0/0/1 3xPL not offered	6
NES-13 14 02-14.1	Molecular Electronics			2/2/0/0/0 PL	6
NES-12 12 05-14.1	Optoelectronics			4/1/0/0/0 2xPL	7
NES-02 04 01	Quantum Mechanics for Nanoelectronics			5/1/0/0/0 PL	7
NES-11 06 07-14.1	Ubiquitous Systems			4/2/0/0/0 PL	7