TECHNISCHE UNIVERSITÄT DRESDEN

Technische Universität Dresden
Fakultät Elektrotechnik und Informationstechnik

Appendix 1 and 2 to the Study Guide for the consecutive Master's program Nanoelectronic Systems

as of 5th July, 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 name	**Adaptive Computing Systems for Robotics**
Module number	INF-NES-E-ACSR
Lecturer in charge	Prof. Dr.-Ing. Diana Göhringer diana.goehringer@tu-dresden.de
Objectives	After completing the module, students have: - knowledge in the areas of design and programming of modern embedded systems for robot applications, - knowledge in the field of robotics in the areas of perception, localization, planning and multi-robot collaboration tasks as well as - practical skills to use embedded operating systems, such as Robotics Operative System, abbreviated ROS, Embedded Linux and the PYNQ - Python Productivity for Zynq, on a modern embedded system such as the Xilinx Zynq System-on-Chip.
Contents	The contents of the module are state-of-the-art FPGA-based robotic computing accelerator designs and their optimized techniques. The module covers the use of FPGAs in robotic perception, localization and planning. In addition to the individual robotic tasks mentioned above, it includes how these can be combined into robotic products such as autonomous vehicles and mobile robots. The module also includes practical experience with robotic and reconfigurable platforms.
Modes of teaching and learning	2 hours per week lectures, 2 hour per week exercises and self-study.
Prerequisites	Knowledge and skills in computer architecture at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 60 minutes. With up to 10 registered students the written exam will be replaced by a non-public oral exam as individual exam of 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 earned by the module. The module grade is the unweighted mean of the grades of the assessments.
Frequency	The module is offered every summer semester.

Workload	The total effort is 180 hours.
Duration	The module takes one semester.

Module name	**Adaptive Laser Systems**
Module number	EuI-NES-E-AdLsy
Lecturer in charge	Prof. Dr.-Ing. habil. Jürgen Czarske juergen.czarske@tu-dresden.de
Objectives	After completing the module, students are able to describe, use and evaluate adaptive laser systems. They know the basics of system design for modern laser sensors.
Contents	The contents of the module are: - laser measurement systems, i.e. basic physics, Gaussian beam, interferometry, Fourier optics, fiber sensors, as well as - experimental applications of laser sensors.
Modes of teaching and learning	2 hours per week lectures, 1 hour per week exercises, 1 hour per week lab courses and self-study.
Prerequisites	Knowledge of physics, systems theory and the fundamentals of optics and photonics at Bachelor's level is required.
Usability	The module is a required elective module in the Master's program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a non-public oral exam as individual exam of 20 minutes and a portfolio of 20 hours. Both examinations must be passed.
Credit points and grades	5 credit points can be earned by the module. The module grade is the weighted mean of the grades of the assessments. The oral exam is weighted by 3/4 and the portfolio is 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 name	**Antennas and Radar Systems**
Module number	EuI-NES-E-ARS
Lecturer in charge	Prof. Dr.-Ing. Dirk Plettemeier dirk.plettemeier@tu-dresden.de
Objectives	After completing the module, 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 contents of the module are 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	4 hours per week lectures, 2 hour per week exercises and self-study.
Prerequisites	Knowledge of high-frequency technology at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a non-public oral exam as individual exam of 45 minutes.
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 assessments.
Frequency	The module is offered every summer semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.

Module name	**Applied Joint Communications and Sensing Systems**
Module number	EuI-NES-E-AJCAS
Lecturer in charge	Prof. Dr.-Ing. Dr. h.c. Gerhard Fettweis gerhard.fettweis@tu-dresden.de
Objectives	After completing the module, students will have 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 content of the module is 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 Bachelor's level, is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 assessment.
Frequency	The module is offered every summer semester.
Workload	The total effort is 150 hours.
Duration	The module takes one semester.

Module name	**Communications**
Module number	EuI-NES-E-Comms
Lecturer in charge	Prof. Dr.-Ing. Dr. h.c. Gerhard Fettweis gerhard.fettweis@tu-dresden.de
Objectives	After completing the module, students know the basic principles and practical application of message transmission. They are able to understand and mathematically describe the basic signal processing procedures in communication systems. They are familiar with baseband and bandpass transmission and know the most important analog and digital modulation methods. They understand the influence of noise on transmission quality for simple analog and digital transmission scenarios. They are able to simulate modules of a telecommunications transmission system.
Contents	The contents of the module are the basic modules of transmission technology, in particular signal theory, i.e. sinusoidal signals, Dirac function, convolution, Fourier transformation; linear time-invariant systems, in particular transfer function, impulse response; bandpass signals, in particular real and complex up- and down-mixing of signals, equivalent low-pass signal; Analog modulation, in particular modulation, demodulation, properties of AM, PM, FM; analog-to-digital conversion, in particular sampling theorem, signal reconstruction, quantization, undersampling and oversampling; digital modulation methods, i.e. modulation methods, matched-filter receivers, bit error probability; as well as more current topics such as the basic idea of multi-antenna transmission and multi-carrier transmission.
Modes of teaching and learning	2 hours per week lectures, 1 hour per week exercises. 1 hour per week lab courses and self-study.
Prerequisites	Knowledge of systems theory for analog and digital systems, algebra, differential and integral calculus, function theory, partial differential equations and probability theory at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 120 minutes. A bonus to the written exam is the completion of 20 hours of exercises.
Credit points and grades	5 credit points can be obtained by the module. The module grade is the grade of the assessment.

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

Module name	**Computational Laser Systems**
Module number	EuI-NES-E-ComLS (EuI-ET-E-ComLS, EuI-IST-E-ComLS, EuI-MT-E-ComLS)
Lecturer in charge	Prof. Dr.-Ing. habil. Jürgen Czarske juergen.czarske@tu-dresden.de
Objectives	After completing the module, 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 contents of the module are 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	Knowledge of physics and systems theory at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a non-public oral 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 assessment.
Frequency	The module is offered every winter semester.
Workload	The total effort is 150 hours.
Duration	The module takes one semester.

Module name	**Deep Neural Network Hardware**
Module number	EuI-NES-E-DNNH (EuI-IST-E-DNNH)
Lecturer in charge	Prof. Dr.-Ing. habil. Christian Georg Mayr christian.mayr@tu-dresden.de
Objectives	After completing 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 content of the module is 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 at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 assessment.
Frequency	The module is offered every summer semester.
Workload	The total effort is 150 hours.
Duration	The module takes one semester.

Module name	**Design and Programming of Embedded Multicore Architectures**
Module number	INF-NES-E-EMA (INF-IST-E-EMA)
Lecturer in charge	Prof. Dr.-Ing. Diana Göhringer ads@mailbox.tu-dresden.de
Objectives	After completing the module, students 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 contents of the module include general and specialized knowledge in the fields of design, simulation and programming of modern embedded systems consisting of several processors and special accelerators. Further contents are the memory and communication infrastructures of embedded multicore architectures, for example network-on-chip as well as the use of embedded operating systems.
Modes of teaching and learning	2 hours per week lectures, 2 hours per week exercises and self-study.
Prerequisites	Basic knowledge and skills in computer architecture at Bachelor's level are required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 60 minutes.
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the assessment.
Frequency	The module is offered every summer semester.
Workload	The total effort is 180 hours.
Duration	The module takes one semester.

Module name	**Electromechanical Networks**
Module number	EuI-NES-E-EMNet
Lecturer in charge	Prof. Dr.-Ing. habil. Uwe Marschner uwe.marschner@tu-dresden.de
Objectives	After completing the module, 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 pSpice. 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	The contents of the module 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	2 hours per week lectures, 1 hours per week exercises, 1 hour per week lab courses and self-study.
Prerequisites	Basic knowledge of analog circuit technology, analysis and linear algebra at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 120 minutes.
Credit points and grades	5 credit points can be obtained by the module. The module grade is the grade of the assessment.
Frequency	The module is offered every winter semester.
Workload	The total effort is 150 hours.
Duration	The module takes one semester.

Accompanying 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 name	**Foundations of Certified Programming Language and Compiler Design**
Module number	EuI-NES-E-FCPL
Lecturer in charge	Dr.-Ing. Sebastian Ertel sebastian.ertel@barkhauseninstitut.org
Objectives	After completing 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 contents of the module are 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	Competencies in programming, logic, data management and software technology at Bachelor's level are required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a non-public oral exam as individual exam of 30 minutes. With more than 15 registered students the oral exam as individual exam will be replaced by a non-public oral exam as group exam of 20 minutes each. 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 assessment.
Frequency	The module is offered every winter semester.
Workload	The total effort is 180 hours.
Duration	The module takes one semester.

Module name	**Foundations of Software Fault Tolerance**
Module number	INF-NES-E-SFT
Lecturer in charge	Prof. Dr. Christof Fetzer se@mailbox.tu-dresden.de
Objectives	After completing the module, students will be able to develop fault-tolerant software systems so that their probability of failure is minimized and their security is increased. Students know the different types and classes of errors and can analyze and evaluate their probability of failure. Furthermore, students are able to apply various principles of robustness in order to minimize the probability of system failure.
Contents	The contents of the module are theoretical basics of different fault-tolerant mechanisms and analysis methods, which can be applied statically or dynamically. The module also covers mechanisms that increase the robustness of distributed systems. In addition to reliability, aspects such as the attack security of such systems are also covered in the module.
Modes of teaching and learning	2 hours per week lectures, 2 hours per week exercises and self-study.
Prerequisites	The knowledge and skills to be acquired in the module Foundations of Systems Engineering are required.
Usability	The module is a required elective module in the Master's program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a non-public oral 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 assessment.
Frequency	The module is offered every summer semester.
Workload	The total effort is 180 hours.
Duration	The module takes one semester.

Module name	**Foundations of Systems Engineering**
Module number	INF-NES-E-SE1
Lecturer in charge	Prof. Dr. Christof Fetzer se@mailbox.tu-dresden.de
Objectives	After completing the module, students will be able to design distributed software platforms using modern hardware and software components. The students understand the challenges of distributed systems in terms of programming and correct execution. They are able to evaluate them and apply appropriate mechanisms.
Contents	The contents of the module are the design, construction and operation of software platforms. This module focuses on current topics in the architecture of distributed systems. These include parallel computing on current hardware, ensuring the composability and security of complex modules, test methods for the fastest possible error detection and the management of human resources to support collaboration.
Modes of teaching and learning	2 hours per week lectures, 2 hours per week exercises and self-study.
Prerequisites	Knowledge and skills in the basics of operating systems, computer architecture and computer networks at Bachelor's level are required.
Usability	The module is a required elective module in the Master's program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 60 minutes.
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the assessment.
Frequency	The module is offered every winter semester.
Workload	The total effort is 180 hours.
Duration	The module takes one semester.

Module name	**Fundamentals of Estimation and Detection**
Module number	EuI-NES-E-FED
Lecturer in charge	PD Dr.-Ing. habil. Wolfgang Rave wolfgang.rave@tu-dresden.de
Objectives	After completing the module, students are familiar with important approaches to parameter estimation and detection as well as the basics of linear estimation methods and memory-based systems. They understand the different mathematical models and approaches on which the common methods are based and are therefore able to select and apply suitable methods for a wide range of practical scenarios. Students are able to evaluate different estimators/detectors based on quality criteria.
Contents	The contents of the module are estimation methods for deterministic parameters and parameters modeled as random variables using a mean square criterion for the estimation error. Special topics are: Cramer-Rao bound, expected variance estimator with minimum variance of the estimation error, maximum likelihood estimator, Bayes estimator, binary hypothesis test.
Modes of teaching and learning	2 hours per week lectures, 2 hours per week exercises and self-study.
Prerequisites	Knowledge of systems theory and basic knowledge of probability theory at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 120 minutes.
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the assessment.
Frequency	The module is offered every winter semester.
Workload	The total effort is 180 hours.
Duration	The module takes one semester.

Module name	**Future Communication Networks**
Module number	EuI-NES-E-FCN (EuI-ET-E-FCN, EuI-IST-E-FCN)
Lecturer in charge	Jun.-Prof. Dr.-Ing. Riccardo Bassoli riccardo.bassoli@tu-dresden.de
Objectives	After completing the module, students will have in-depth knowledge of future communication networks such as quantum, molecular, etc. and their performance evaluation. They will be familiar with the processes and protocol structures in future communication networks. They are able to gain an overview of future technologies and their development directions and are familiar with methods of investigation using prototyping and implementation. Students are familiar with the most important network technologies, their functional principles and protocols, can apply these to new problems and correctly model, analyze and evaluate the performance of systems.
Contents	The content of the module is the consideration of future communication networks with selected technologies and protocols such as quantum, molecular, post-Shannon and others as well as routing in communication networks with in-depth consideration of the associated protocols as well as the methods of prototyping and the implementation and performance evaluation of communication networks. The focus is on the study and design methods for the physical and link layer functions.
Modes of teaching and learning	2 hours per week lectures, 1 hour per week exercises, 1 hour peer week lab courses and self-study.
Prerequisites	Basic knowledge of communications engineering and communications networks at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 120 minutes and a complex exam of 40 hours. With up to 15 registered students the written exam will be replaced by a non-public oral exam as individual exam of 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	5 credit points can be obtained by the module. The module grade is the weighted mean of the grades of the assessments. The written exam/ oral exam is weighted by 3/4 and the complex exam is weighted by 1/4.

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

Module name	**German Language and Culture**
Module number	EuI-NES-E-GLC
Lecturer in charge	Monika Ruszó monika.ruszo@tu-dresden.de
Objectives	After completing the module, students have elementary language skills in German at level A1 of the Common European Framework of Reference for Languages. Students will be able to grasp slowly and clearly articulated concrete information on familiar everyday topics, understand simple and short texts with a focus on key words by reading syntactically, semantically, lexically and morphologically, infer the meanings of unknown concrete terms from the context and express themselves about their environment using simple, mainly isolated phrases and respond appropriately to simple questions.
Contents	The contents of the module are: - individually familiar names, words and simple sentences as well as listening texts on everyday situations, especially in a university environment, - elementary oral and written simple, isolated phrases and sentences as well as interaction on this topic, - development of relevant reading and listening strategies, - development of simple grammatical structures and an appropriate vocabulary and - automation exercises in various forms of work and with different media.
Modes of teaching and learning	4 hours per week language courses and self-study.
Prerequisites	No special knowledge 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 of 60 minutes.
Credit points and grades	5 credit points can be obtained by the module. The module grade is the grade of the assessment.
Frequency	The module is offered every semester.
Workload	The total effort is 150 hours.
Duration	The module takes one semester.

Module name	**Hardware Modeling and Simulation**
Module number	INF-NES-E-HMS (INF-IST-E-HMS)
Lecturer in charge	Prof. Dr.-Ing. Diana Göhringer diana.goehringer@tu-dresden.de
Objectives	After completing the module, students 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 an 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	2 hours per week lectures, 2 hours per week exercises and self-study.
Prerequisites	Programming skills in C/C++ as well as basic knowledge and skills in technical computer science at Bachelor's level are required.
Usability	The module is a required elective module in the Master's program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 60 minutes.
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the assessment.
Frequency	The module is offered every winter semester.
Workload	The total effort is 180 hours.
Duration	The module takes one semester.

Module name	**Innovative Concepts for Active Nanoelectronic Devices**
Module number	EuI-NES-E-ICAND (EuI-ET-E-ICAND)
Lecturer in charge	Prof. Dr.-Ing. Thomas Mikolajick thomas.mikolajick@tu-dresden.de
Objectives	After completing the module, students will be able to recognize materials science boundary conditions based on their knowledge of the structure, properties, production and structure formation of materials and the effects and basic types of small structures of component concepts, applications and future trends as well as bottom-up and top-down nanoelectronics concepts. Furthermore, they are able to design innovative concepts for active components and systems of nanoelectronics and to understand physical effects and transport mechanisms. They recognize concrete designs for components, that are currently in use or that are in research or development stage, and their technological and electrical boundary conditions.
Contents	The contents of the module are innovative semiconductor components and nanoelectronic materials.
Modes of teaching and learning	4 hours per week lectures, 1 hour per week exercises, 1 hour peer week lab courses and self-study.
Prerequisites	Competencies in the basics of physics, semiconductor electronics and electronic components are required.
Usability	The module is a required elective module in the Master's program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 120 minutes. With up to 20 registered students the written exam will be replaced by a non-public oral exam as individual exam of 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 grade of the assessment.
Frequency	The module is offered every winter semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.

Module name	**Integrated Circuits for Broadband Optical Communications**
Module number	EuI-NES-E-ICBC (EuI-ET-E-ICBC, EuI-IST-E-ICBC)
Lecturer in charge	Prof. Dr. sc. techn. Frank Ellinger frank.ellinger@tu-dresden.de
Objectives	After completing the module, students are able to understand and apply the fundamentals and methods of designing fast integrated circuits and systems for optical broadband communication. They are able to analyze and optimize these circuits and learn about design tools for circuits.
Contents	The contents of the module are integrated circuits for optical broadband communication such as transimpedance amplifiers, detector circuits, laser drivers, multiplexers, frequency dividers, oscillators, phase-locked loops, synthesizers and data recovery circuits.
Modes of teaching and learning	3 hours per week lectures, 1 hour per week exercises, 2 hours per week lab courses and self-study.
Prerequisites	Basic knowledge of circuit technology at Bachelor's level is required.
Usability	The module is a required elective module in the Master's program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 120 minutes.
Credit points and grades	7 credit points can be obtained by the module. The module grade is the grade of the assessment.
Frequency	The module is offered every winter semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.

Module name	**Integrated Photonic Devices for Communications and Signal Processing**
Module number	EuI-NES-E-IPD
Lecturer in charge	Prof. Dr.-Ing. Kambiz Jamshidi kambiz.jamshidi@tu-dresden.de
Objectives	After completing the module, students are familiar with the theoretical principles and technologies for various integrated optical components with a focus on communication and signal processing. They are able to build such components on a semiconductor basis, i.e. silicon. They are able to analyze and synthesize these components using various analytical and numerical methods.
Contents	The contents of the module are modeling, design and simulation of basic components, including passive components such as waveguides, couplers, gratings, interferometers, resonators and filters as well as high-speed electro-optical modulators such as Mach-Zehnder and micro-ring, electro-absorption modulators, high-speed photodiodes and lasers.
Modes of teaching and learning	4 hours per week lectures, 2 hours peer week lab courses and self-study.
Prerequisites	Knowledge of electromagnetism and semiconductors at Bachelor's level is required.
Usability	The module is a required elective module in the Master's program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a complex exam of 30 hours.
Credit points and grades	7 credit points can be obtained by the module. The module grade is the grade of the assessment.
Frequency	The module is offered every winter semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.
Accompanying literature	G. T. Reed (ed.), Silicon Photonics: The State of the Art (Wiley, 2008). A. Yariv and P. Yeh, Photonics, 6th ed (Oxford, 2007).

Module name	**Introduction to Optical Non-classical Computing: Concepts and Devices**
Module number	EuI-NES-E-ONC (EuI-IST-E-ONC)
Lecturer in charge	Prof. Dr.-Ing. Kambiz Jamshidi kambiz.jamshidi@tu-dresden.de
Objectives	After completing the module, students know the fundamentals of quantum optics and statistical optics. They are familiar with various optical computing methods such as quantum computing, artificial neural networks and Ising machines. They understand the various linear and non-linear photonic components required for optical computing.
Contents	Contents of the module are methods of optical non-classical computing and basics of relevant photonic devices.
Modes of teaching and learning	4 hours per week lectures, 2 hours peer week exercises and self-study.
Prerequisites	Knowledge of electromagnetism, systems theory and semiconductors at Bachelor's level is required.
Usability	The module is a required elective module in the Master's program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a complex exam of 30 hours.
Credit points and grades	7 credit points can be obtained by the module. The module grade is the grade of the assessment.
Frequency	The module is offered every summer semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.
Accompanying literature	- Quantum Computations and Quantum Information by M. Nielsen and I. L. Chuang - Adiabatic Quantum Computation and Quantum Annealing: Theory and Practice by C. C. McGeoch - Principles of Artificial Neural Networks by D. Graupe

Module name	**Joint Communications and Sensing Systems for 6G Networks**
Module number	EuI-NES-E-JCAS
Lecturer in charge	Prof. Dr.-Ing. Dr. h.c. Gerhard Fettweis gerhard.fettweis@tu-dresden.de
Objectives	After completing the module, students have a comprehensive understanding of joint communications and sensing technology at the system level. They 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 are 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 peer week exercises and self-study.
Prerequisites	Knowledge of electrical engineering or computer science and basic mathematics at Bachelor's level are required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 assessment.
Frequency	The module is offered every winter semester.
Workload	The total effort is 150 hours.
Duration	The module takes one semester.

Module name	**Materials for the 3D System Integration**
Module number	EuI-NES-E-3DSI
Lecturer in charge	Prof. Dr.-Ing. Dr. h.c. Karlheinz Bock karlheinz.bock@tu-dresden.de
Objectives	After completing the module, students are familiar with the technologies for manufacturing miniaturized 3D and 2.5D components as well as Si interposers with TSVs. They are able to select the material systems for the 3D structures and know their influence on reliability. Students are familiar with new concepts for the use of nanomaterials in 3D structures.
Contents	The content of the module is 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
Modes of teaching and learning	4 hours per week lectures, 1 hour per week lab courses, one excursion and self-study.
Prerequisites	Competencies in the field of materials science at Bachelor's level as well as knowledge of semiconductor technology and packaging and connection technology are required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 and a complex exam of 32 hours.
Credit points and grades	7 credit points can be obtained by the module. The module grade is the unweighted mean of the grades of the assessments.

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 name	**Memory Technology**
Module number	EuI-NES-E-MemTe (EuI-ET-E-MemTe, EuI-IST-E-MemTe)
Lecturer in charge	Prof. Dr.-Ing. Thomas Mikolajick thomas.mikolajick@tu-dresden.de
Objectives	After completing the module, students have the comeptencies to optimize and develop new generetions of existing memory concepts. Based on the physical effects they are also able to devolp new memory concepts. Furthermore, the students are able to evaluate areas of application for the memory concept and are aware of their limitation.
Contents	his 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).
Modes of teaching and learning	4 hours per week lectures, 2 hours per week seminars and self-study.
Prerequisites	Basic knowledge of electronic components at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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. With up to 20 registered students the written exam will be replaced by a non-public oral exam as individual exam of 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 unweighted mean of the grades of the assessments.
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 name	**Molecular Electronics**
Module number	MW-NES-E-MoEl
Lecturer in charge	Prof. Dr. Artur Erbe a.erbe@hzdr.de
Objectives	After completing the module, students are familiar with the fundamentals of molecular electronics and the most important experimental and theoretical methods for investigating charge transport on the molecular scale.
Contents	The contents of the module are experimental methods, physical effects and theoretical tools, for example single molecule electronics, scanning probe and break-junction, techniques, transport mechanisms on the nanoscale, molecular components such as diodes, transistors, molecular machines and molecular architectures.
Modes of teaching and learning	2 hours per week lectures, 2 hours per week exercises and self-study.
Prerequisites	Basic knowledge of mathematics and theoretical physics at Bachelor's level is required. The following literature is recommended: J.P. Launay and M. Verdaguer: Electrons in molecules, revised edition, Oxford 2017 J.C. Cuevas and E. Scheer, Molecular electronics, World Scientific 2010
Usability	The module is a required elective module in the Master's program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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. With up to 10 registered students the written exam will be replaced by a non-public oral exam as individual exam of 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	5 credit points can be obtained by the module. The module grade is the grade of the assessment.
Frequency	The module is offered every winter semester.
Workload	The total effort is 150 hours.

Duration	The module takes one semester.

Module name	**Nanostructured Materials**
Module number	MW-NES-E-NSM
Lecturer in charge	Prof. Dr. Gianaurelio Cuniberti gianaurelio.cuniberti@tu-dresden.de
Objectives	After completing the module, students are familiar with the fundamentals of physics with regard to the production and properties of nanostructured materials, in particular the synthesis of clusters and nanotubes, nanostructuring using electron beam lithography, optical lithography and scanning microscopy. In addition, they know the theoretical principles of scanning force microscopy. They know relevant quantum effects in mesoscopic systems, concepts of scaling laws, density of states and giant magnetoresistance. Students are familiar with electron transport in low-dimensional solid-state materials and individual electronics.
Contents	The contents of the module are the theoretical basics of atomic force microscopy. Furthermore, relevant quantum effects in mesoscopic systems, concepts of scaling laws, density of states and giant magnetoresistance are covered. The module also covers electron transport in low-dimensional solid-state materials and individual electronics.
Modes of teaching and learning	2 hours per week lectures, 2 hours per week exercises, 2 hours per week lab courses and self-study.
Prerequisites	Basic knowledge of mathematics and theoretical physics at Bachelor's level is required. The following literature is recommended: - E.L. Wolf: Nanophysics and nanotechnology, Wiley-VCH 2006 - R. Waser: Nanoelectronics and information technology, Wiley-VCH 2005 - C.W. Shong, S.C. Haur, A.T.S. Wee: Science at the nanoscale, Pan Stanford Publ. 2010 - V.V. Mitin, V.A. Kochelap, M. A. Stroscio: Introduction to nanoelectronics, Cambridge 2008 - D.A. Bonnell: Scanning tunneling microscopy and spectroscopy, VCH Weinheim 1993 - A.P. Sutton: Electronic structure of materials, Oxford 1996 - W.R. Fahrner (Ed.): Nanotechnology and nanoelectronics, Springer 2005

Usability	The module is a required elective module in the Master's program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 and a complex exam of 10 hours. With up to 10 registered students the written exam will be replaced by a non-public oral exam as individual exam of 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 the unweighted mean of the grades of the assessments.
Frequency	The module is offered every summer semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.

Module name	**Nanoscience**
Module number	PHY-NES-E-NanSc
Lecturer in charge	Prof. Dr. phil. II habil. Lukas Eng lukas.eng@tu-dresden.de
Objectives	After completing the module, students are able to independently understand the physical and chemical principles of nanotechnology and discuss their impact using case studies. They know and understand the measurement procedures and principles of how physical data can be obtained quantitatively on the nanometer length scale with the aid of modern scanning probe microscopes.
Contents	The contents of the module are the physical and chemical basics for understanding nanotechnology, the analysis of the advantages and disadvantages of bottom-up and top-down approaches in nanotechnology, the production of functional nanostructures for electronic, optical, magnetic and other applications, the introduction to metrology on the 1 nm length scale, consideration of the physics, functionality and realization of measuring instruments based on scanning probe microscopy, analysis and manipulation on the atomic scale.
Modes of teaching and learning	4 hours per week lectures, 1 hour per week tutorials and self-study.
Prerequisites	Knowledge of the basics of physics and chemistry at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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. With up to 10 registered students the written exam will be replaced by a non-public oral exam as individual exam of 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 assessment.
Frequency	The module is offered every summer semester.
Workload	The total effort is 180 hours.
Duration	The module takes one semester.

Module name	**Nano&Optics**
Module number	PHY-NES-E-NanOp
Lecturer in charge	Prof. Dr. phil. II habil. Lukas Eng lukas.eng@tu-dresden.de
Objectives	After completing the module, students are able to independently understand the physical principles of optics, laser optics and interfacial optics on a macroscopic and nanoscopic length scale and to discuss and calculate their impact using case studies. They are also familiar with the technical basics.
Contents	The contents of the module are the physical fundamentals of electromagnetic waves in air and matter, the physics of spontaneous and stimulated photonic processes, interaction and effects of linear optical waves with matter on a macroscopic - far field - and nanoscopic - near field - scale, the differentiation, production and characterization of propagating and evanescent waves, the laser principle and its application/implementation.
Modes of teaching and learning	4 hours per week lectures, 1 hour per week tutorials and self-study.
Prerequisites	Knowledge of the basics of physics and chemistry at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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. With up to 10 registered students the written exam will be replaced by a non-public oral exam as individual exam of 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 assessment.
Frequency	The module is offered every semester.
Workload	The total effort is 180 hours.
Duration	The module takes two semesters.

Module name	**Neural Networks and Memristive Hardware Accelerators**
Module number	EuI-NES-E-NNMHA (EuI-IST-E-NNMHA)
Lecturer in charge	Prof. Dr. phil. nat. habil. Ronald Tetzlaff ronald.tetzlaff@tu-dresden.de
Objectives	After completing 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 are 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.
Contents	The 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	2 hours per week lectures, 2 hours per week projects, 2 hours per week lab courses and self-study.
Prerequisites	Basic knowledge of electrical engineering and computer science at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 180 minutes and a complex exam of 60 hours. The written exam muss be passed.
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 assessments. The written exam is weighted by 4/5 and the complex exam is weighted by 1/5.

Frequency	The module is offered every winter semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.

Module name	**Neuromorphic VLSI Systems**
Module number	EuI-NES-E-NVLSI (EuI-ET-E-NVLSI, EuI-IST-E-NVLSI)
Lecturer in charge	Prof. Dr.-Ing. habil. Christian Georg Mayr christian.mayr@tu-dresden.de
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.
Contents	The contents of the module are: - 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.
Modes of teaching and learning	4 hours per week lectures, 2 hours per week exercises and self-study.
Prerequisites	Knowledge of circuit technology and system theory at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a portfolio in the amount of 30 hours and a non-public oral exam as individual exam of 20 minutes.
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 assessments. The portfolio is weighted by 2/3 and the oral exam is 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 name	**Optoelectronic Devices and Systems**
Module number	EuI-NES-E-OPTO
Lecturer in charge	Prof. Dr.-Ing. Hubert Lakner hubert.lakner@tu-dresden.de
Objectives	After completing the module, students are familiar with important optical phenomena such as light generation, radiative and non-radiative recombination processes, color effects and others and their use in optical components. They know how optoelectronic components and systems work, how they are manufactured and how they are used in technical applications. They have knowledge of the necessary theoretical principles.
Contents	The contents of the module are the fundamentals of optoelectronic components and systems and their technical realization, such as LEDs, laser diodes, double heterostructures/ compound semiconductors, multi-quantum wells and quantum dots. Other topics include displays, modulators, scanners, optical memories and micro-opto-electro-mechanical systems for modulating and deflecting light. The module also includes methods for manufacturing opto-electrical systems and for calibrating and characterizing optical micro-electro-mechanical systems.
Modes of teaching and learning	2 hours per week lectures, 1 hour per week exercises, 1 hour per week lab courses and self-study.
Prerequisites	Basic knowledge of technical optics at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a non-public oral exam as individual exam of 20 minutes. A bonus to the oral exam is a practical training report in the amount of 15 hours.
Credit points and grades	5 credit points can be obtained by the module. The module grade is the grade of the assessment.
Frequency	The module is offered every winter semester.
Workload	The total effort is 150 hours.
Duration	The module takes one semester.

Module name	**Physical Design**
Module number	EuI-NES-E-PD
Lecturer in charge	Prof. Dr.-Ing. Gerhard Fettweis gerhard.fettweis@tu-dresden.de
Objectives	After completing the 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: - basic knowledge of CMOS circuits and their differentiation from analog circuit implementations - concepts of the physical design process such as partitioning, floor planning, place and route - introduction to the concepts of design-optimizing algorithms and their application in VLSI design automation - formulating challenges and their solution strategies for a realistic circuit design - implementing the physical design processes with the help of modern VLSI development tools.
Contents	The contents of the module are - 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.
Modes of teaching and learning	2 hours per week lectures, 1 hour per week lab courses and self-study. Participation in the lectures and lab courses is limited to 50 participants.
Prerequisites	Knowledge of digital circuit technology and microprocessor architectures at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.

Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a complex exam of 30 hours.
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the assessment.
Frequency	The module is offered every summer semester.
Workload	The total effort is 180 hours.
Duration	The module takes one semester.

Module name	**Plasma Technology**
Module number	EuI-NES-E-PlaTe (EuI-ET-E-PlaTe, EuI-IST-E-PlaTe)
Lecturer in charge	Prof. Dr. rer. nat. habil. Elizabeth von Hauff elizabeth.von_hauff@tu-dresden.de
Objectives	After completing 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 at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 assessment.
Frequency	The module is offered every winter semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.

Module name	**Quantum Mechanics for Nanoelectronics**
Module number	PHY-NES-E-QMNE
Lecturer in charge	Prof. Dr. Manfred Helm manfred.helm@tu-dresden.de
Objectives	After completing the module, students know the fundamentals of quantum mechanics and its application in periodic solids. They are familiar with the treatment of the hydrogen problem and the time-dependent perturbation calculation. In particular, they are able to apply the Schrödinger equation independently to one-dimensional problems. Students are familiar with semiconductor nanostructures, i.e. two-, one- and zero-dimensional structures, quantum wells, wires and dots, their production and energy levels, electron transport and optical absorption in them, their application to components and the influence of a magnetic field.
Contents	The contents of the module are the fundamentals of quantum mechanics with application to solid-state physics and nanoelectronics. It lays the foundations for a microscopic understanding of electronic materials and components.
Modes of teaching and learning	5 hours per week lectures, 1 hour per week exercises and self-study.
Prerequisites	Knowledge of physics at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a non-public oral exam as individual exam of 30 minutes.
Credit points and grades	7 credit points can be obtained by the module. The module grade is the grade of the assessment.
Frequency	The module is offered every winter semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.

Module name	**Requirements and methodologies for design of integrated circuits from industrial production perspective**
Module number	EuI-NES-E-LSer
Lecturer in charge	Prof. Dr. Stefan E. Schulz stefan.schulz@zfm.tu-chemnitz.de
Objectives	After completing the module, 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 at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 assessment.
Frequency	The module is offered every summer semester.
Workload	The total effort is 150 hours.
Duration	The module takes one semester.

Module name	**Resource Management**
Module number	WIWI-NES-E-ResM
Lecturer in charge	Dean of Studies of Fasculty of Business and Economics studiendekan.ww@mailbox.tu-dresden.de
Objectives	After completing 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 solve problems independently in groups and present their proposed solutions in written form.
Contents	The content of the module is the consideration of environmental resources in order to evaluate them with regard to environmentally relevant aspects and to integrate them into business decisions. In addition, instruments for ecology-oriented evaluation and decision-making in the company, ecology-oriented corporate strategies for increasing corporate value and environmental management systems for adequate resource management are considered.
Modes of teaching and learning	2 hours per week lectures, 2 hours per week projects and self-study.
Prerequisites	Knowledge of business administration at Bachelor's level is required. Furthermore, English language skills at level B2+ of the Common European Framework of Reference for Languages are recommended.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a complex exam of 80 hours.
Credit points and grades	5 credit points can be obtained by the module. The module grade is the grade of the assessment.
Frequency	The module is offered every summer semester.
Workload	The total effort is 150 hours.
Duration	The module takes one semester.

Module name	**Stochastic Signals and Systems**
Module number	EuI-NES-E-StSig
Lecturer in charge	Prof. Dr.-Ing. Rafael F. Schaefer rafael.schaefer@tu-dresden.de
Objectives	After completing the module, students know the description methods of stochastic signals as realizations of stochastic processes. They are able to calculate the behavior of determinate and stochastic systems under the condition that they process stochastic processes.
Contents	The contents of the module are methods for the investigation of static and dynamic systems under the influence of stochastic signals. This includes: - the fundamentals of one- and multi-dimensional random variables based on probability theory, the definition of the random process and methods for its mathematical description with continuous and discrete time, - the transmission of stochastic signals through systems, in particular for non-linear static systems with transformation of the density function and for linear dynamic systems with transformation of the power density spectrum and - various applications, for example the calculation and comparison of the thermal noise behavior of electrical components and circuits or the improvement of the signal-to-noise ratio using discrete-time systems.
Modes of teaching and learning	2 hours per week lectures, 2 hours per week exercises and self-study.
Prerequisites	Fundamentals of the theory of determinate systems and basic knowledge of probability theory at Bachelor's level are required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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	6 credit points can be obtained by the module. The module grade is the grade of the assessment.
Frequency	The module is offered every winter semester.
Workload	The total effort is 180 hours.

Duration	The module takes one semester.
Module name	**VLSI Processor Design**
Module number	EuI-NES-E-VLSI (EuI-ET-E-VLSI, EuI-IST-E-VLSI)
Lecturer in charge	Prof. Dr.-Ing. habil. Christian Georg Mayr christian.mayr@tu-dresden.de
Objectives	fter completion of this module, students are 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).
Contents	The contents of the module are: - 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
Modes of teaching and learning	2 hours per week lectures, 2 hours per week exercises, 2 hours per week lab courses and self-study.
Prerequisites	Knowledge of circuit technology and system theory at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
Requirements for the award of credit points	The credit points are awarded when the module assessment is passed. The module assessment consists of a complex exam of 50 hours.

Credit points and grades	7 credit points can be obtained by the module. The module grade is the grade of the assessment.
Frequency	The module is offered every summer semester.
Workload	The total effort is 210 hours.
Duration	The module takes one semester.

Module name	**Wireless Sensor Networks**
Module number	INF-NES-E-WSN (INF-IST-E-WSN)
Lecturer in charge	Dr.-Ing. habil. Waltenegus Dargie waltenegus.dargie@tu-dresden.de
Objectives	After completing the module, 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.
Contents	The contents of the module are self-management algorithms, media access methods, routing algorithms, localization technologies and data management tools for wireless sensor networks.
Modes of teaching and learning	2 hours per week lectures, 2 hours per week exercises and self-study.
Prerequisites	Basic knowledge of computer architecture, distributed systems, mobile communication and software engineering at Bachelor's level is required.
Usability	The module is a required elective module in the Master’s program Nanoelectronic Systems. It creates the prerequisites for the modules that list that module in the "Prerequisites" field.
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 60 minutes.
Credit points and grades	6 credit points can be obtained by the module. The module grade is the grade of the assessment.
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

Appendix 2 Part 2: Required elective modules' curriculum plan of 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

Module number	Module name	1st semester	2nd semester	3rd semester	CP
		V/Ü/P	V/Ü/P	V/Ü/P (M)	
INF-NES-E-SE1	Foundations of Systems Engineering	2/2/0 PL			6
EuI-NES-E-GLC	German Language and Culture	0/0/0 4 SWS language courses PL			5
EuI-NES-E-JCAS	Joint Communications and Sensing Systems for 6G Networks	2/2/0 PL			5
EuI-NES-E-NNMHA	Neural Networks and Memristive Hardware Accelerators	2/0/2 2 SWS projects 2xPL			7
EuI-NES-E-PlaTe	Plasma Technology	4/2/0 PL			7
EuI-NES-E-StSig	Stochastic Signals and Systems	2/2/0 PL			6
INF-NES-E-ACSR	Adaptive Computing Systems for Robotics		2/2/0 PL		6
NES-E-AdLsy	Adaptive Laser Systems		2/1/1 2 PL		5
EuI-NES-E-ARS	Antennas and Radar Systems		4/2/0 PL		7
EuI-NES-E-AJCAS	Applied Joint Communications and Sensing Systems		2/2/0 PL		5
EuI-NES-E-Comms	Communications		2/1/1 PL		5
EuI-NES-E-DNNH	Deep Neural Network Hardware		2/2/0 PL		5
INF-NES-E-EMA	Design and Programming of Embedded Multicore Architectures		2/2/0 PL		6
INF-NES-E-SFT	Foundations of Software Fault Tolerance		2/2/0 PL		6

Module number	Module name	1st semester	2nd semester	3rd semester	CP
		V/Ü/P	V/Ü/P	V/Ü/P (M)	
EuI-NES-E-ONC	Introduction to Optical Non-classical Computing: Concepts and Devices		4/2/0 PL		7
PHY-NES-E-NanSc	Nanoscience		4/0/0 1 SWS tutorials PL		6
MW-NES-E-NSM	Nanostructured Materials		2/2/2 2xPL		7
EuI-NES-E-NVLSI	Neuromorphic VLSI Systems		4/2/0 2xPL		7
EuI-NES-E-PD	Physical Design		2/0/1 PL		6
EuI-NES-E-LSer	Requirements and methodologies for design of integrated circuits from indus-trial production perspective		4/0/0 PL		5
WIWI-NES-E-ResM	Resource Manage-ment		2/0/0 2 SWS projects PL		5
EuI-NES-E-VLSI	VLSI Processor Design		2/2/2 PL		7
INF-NES-E-WSN	Wireless Sensor Networks		2/2/0 PL		6
EuI-NES-E-3DSI	Materials for the 3D System Integration		2/0/0 PL	2/0/1 1 day excursion PL	7
EuI-NES-E-MemTe	Memory Technology		2/0/0 1 SWS seminars	2/0/0 1 SWS seminars PL	7
PHY-NES-E-NanOp	Nano&Optics		2/0/0	2/0/0 1 SWS tutorials PL	6
EuI-NES-E-ComLS	Computational Laser Systems			3/1/0 PL	5
EuI-NES-E-EM-Net	Electromechanical Networks			2/1/1 PL	5

Module number	Module name	1st semester	2nd semester	3rd semester	CP
		V/Ü/P	V/Ü/P	V/Ü/P (M)	
EuI-NES-E-FCPL	Foundations of Certified Programming Language and Compiler Design			2/2/0 PL	6
EuI-NES-E-FCN	Future Communication Networks			2/1/1 2xPL	5
INF-NES-E-HMS	Hardware Modeling and Simulation			2/2/0 PL	6
EuI-NES-E-I-CAND	Innovative Concepts for Active Nanoelectronic Devices			4/1/1 PL	7
EuI-NES-E-ICBC	Integrated Circuits for Broadband Optical Communications			3/1/2 PL	7
EuI-NES-E-IPD	Integrated Photonic Devices for Communications and Signal Processing			4/0/2 PL	7
MW-NES-E-MoEl	Molecular Electronics			2/2/0 PL	5
EuI-NES-E-OPTO	Optoelectronic Devices and Systems			2/1/1 PL	5
PHY-NES-E-QMNE	Quantum Mechanics for Nanoelectronics			5/1/0 PL	7

V lecture
Ü exercise
P lab course
PL assessment(s)
LP credit points
SWS hours per week (1 SWS=45 minutes)
M option to go abroad

Appendix 2 Part 3: Required elective modules' curriculum plan of 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
Students have to choose 3 modules in the amount of 15 credit points.

Module number	Module name	1st semester	2nd semester	3rd semester	LP
		V/Ü/P	V/Ü/P	V/Ü/P (M)	
INF-NES-C-CONF	Confidential Computing	2/2/0 PL			6
INF-NES-E-SE1	Foundations of Systems Engineering	2/2/0 PL			6
EuI-NES-E-GLC	German Language and Culture	0/0/0 4 SWS language courses PL			5
EuI-NES-E-JCAS	Joint Communications and Sensing Systems for 6G Networks	2/2/0 PL			5
EuI-NES-E-NNMHA	Neural Networks and Memristive Hardware Accelerators	2/0/2 2 SWS projects 2xPL			7
EuI-NES-E-PlaTe	Plasma Technology	4/2/0 PL			7
EuI-NES-E-StSig	Stochastic Signals and Systems	2/2/0 PL			6
INF-NES-E-ACSR	Adaptive Computing Systems for Robotics		2/2/0 PL		6
NES-E-AdLsy	Adaptive Laser Systems		2/1/1 2 PL		5
EuI-NES-E-ARS	Antennas and Radar Systems		4/2/0 PL		7
EuI-NES-E-AJCAS	Applied Joint Communications and Sensing Systems		2/2/0 PL		5
EuI-NES-E-Comms	Communications		2/1/1 PL		5
EuI-NES-E-DNNH	Deep Neural Network Hardware		2/2/0 PL		5
INF-NES-E-EMA	Design and Programming of Embedded Multicore Architectures		2/2/0 PL		6
INF-NES-E-SFT	Foundations of Software Fault Tolerance		2/2/0 PL		6

Module number	Module name	1st semester	2nd semester	3rd semester	LP
		V/Ü/P	V/Ü/P	V/Ü/P (M)	
EuI-NES-C-HwSwC	Hardware/Software Codesign		2/2/0 PL		5
EuI-NES-E-ONC	Introduction to Optical Non-classical Computing: Concepts and Devices		4/2/0 PL		7
PHY-NES-E-NanSc	Nanoscience		4/0/0 1 SWS tutorials PL		6
MW-NES-E-NSM	Nanostructured Materials		2/2/2 2xPL		7
EuI-NES-E-NVLSI	Neuromorphic VLSI Systems		4/2/0 2xPL		7
EuI-NES-E-PD	Physical Design		2/0/1 PL		6
EuI-NES-C-RFIC	Radio Frequency Integrated Circuits		3/1/2 PL		8
EuI-NES-E-VLSI	VLSI Processor Design		2/2/2 PL		7
INF-NES-E-WSN	Wireless Sensor Networks		2/2/0 PL		6
EuI-NES-E-3DSI	Materials for the 3D System Integration		2/0/0 PL	2/0/1 1 day excursion PL	7
EuI-NES-E-MemTe	Memory Technology		2/0/0 1 SWS seminars	2/0/0 1 SWS seminars PL	7
PHY-NES-E-NanOp	Nano&Optics		2/0/0	2/0/0 1 SWS tutorials PL	6
EuI-NES-E-ComLS	Computational Laser Systems			3/1/0 PL	5
EuI-NES-E-EMNet	Electromechanical Networks			2/1/1 PL	5
EuI-NES-E-FCPL	Foundations of Certified Programming Language and Compiler Design			2/2/0 PL	6
EuI-NES-E-FED	Fundamentals of Estimation and Detection			2/2/0 PL	6
EuI-NES-E-FCN	Future Communication Networks			2/1/1 2xPL	5

Module number	Module name	1st semester	2nd semester	3rd semester	LP
		V/Ü/P	V/Ü/P	V/Ü/P (M)	
INF-NES-E-HMS	Hardware Modeling and Simulation			2/2/0 PL	6
EuI-NES-E-ICAND	Innovative Concepts for Active Nanoelectronic Devices			4/1/1 PL	7
EuI-NES-E-ICBC	Integrated Circuits for Broadband Optical Communications			3/1/2 PL	7
EuI-NES-E-IPD	Integrated Photonic Devices for Communications and Signal Processing			4/0/2 PL	7
MW-NES-E-MoEl	Molecular Electronics			2/2/0 PL	5
EuI-NES-E-OPTO	Optoelectronic Devices and Systems			2/1/1 PL	5
PHY-NES-E-QMNE	Quantum Mechanics for Nanoelectronics			5/1/0 PL	7

V lecture
Ü exercise
P lab course
PL assessment(s)
LP credit points
SWS hours per week (1 SWS=45 minutes)
M option to go abroad