Technische Universität Dresden

# Directory of Modules for Visiting Students *Diplom* Programme in Information Systems Engineering

Faculty of Electrical and Computer Engineering

Information Package for International Visiting and Exchange Students

January 2026, **valid as of winter semester 2026/27**

FAKULTÄT **ELEKTROTECHNIK** UND **INFORMATIONSTECHNIK**

# Description

The Faculty of Electrical and Computer Engineering and the Faculty of Computer Science at the Technische Universität Dresden offer the Diplom degree **programme in Information Systems Engineering**. This programme is an integrated five-year (single-tier) programme and thus **includes Bachelor as well as Master's level**.

# Structure

The degree programme in Information Systems Engineering is divided into **basic studies and main studies**. The **basic studies** include **semester 1-4** (= first and second year of the programme); the **main studies** include **semester 5-10** (= third until fifth year of the programme).

The programme **comes in modules**. Each module **consists of 1, 2, 3 or 4 parts, i.e. courses**. Mostly the courses' name is equivalent to the module name but sometimes it differs.

**You must visit all parts/courses of one module!**
**Also, you have to choose minimum 70% of the modules offered by the Faculty of Electrical and Computer Engineering!**

# Language of instruction

The study programme is held in **German and English.**
Students who apply for this study programme should have **German language skills** of at least **B1**.

# Specialization areas

Within the **main studies, there are 5 specialization areas**:

- Automation, Sensors and Robotics / Automation, Sensorik und Robotik
- Electronic Circuits and Systems / Elekronische Schaltungen und Systeme
- Communication Technology / Kommunikationstechnik
- Microelectronics / Mikroelektronik
- Computer Science / Informatik

**In order to avoid timetable conflicts you should choose from one spezialisation area!**

# Content of the following module catalogue

# FAQ

The FAQ shall answer any questions about the module catalogue.

## Why is it called modules but not courses?

Each module consists of 1,2, 3 or 4 parts, i.e. courses. Mostly, if it is just one part, the course name is equivalent to the module name.

## In which semester are the modules offered?

Please look in the columns “winter semester” / “summer semester”.
The academic year at the TU Dresden is divided into the winter semester (October–March) and summer semester (April–September). The semester dates for the following academic years can be found here.
Our module descriptions inform you in which semester, i.e. winter or summer semester, the respective module is offered. When setting up your learning agreement it is important to consider at first which semester you are coming to the TU Dresden (either the winter or summer semester) and then choose appropriate modules.

## What level does the module have?

Please look in the columns “1st semester”, “2nd semester” etc. to find out the semester when it is held. Basic studies are from 1st-4th semester; main studies from 5th-10th semester.

## Why are the 8th, 9th and 10th semester not indicated?

This is due to structural reasons. In the 9th semester the students do an internship and in the 10th semester the students write their final thesis. So, all courses on Master level are indicated in 6th and 7th semester.

## How long is an “hour per week”?

An hour per week (German: SWS =Semesterwochenstunde) is one lesson of 45 minutes per week during the teaching period.
At the TU Dresden, **lessons** usually last for **90 minutes**, i.e. one double lesson (German: Doppelstunde (DS).
1 double lesson (Doppelstunde) = 2 hours per week (Semesterwochenstunde)

## What does L/T/P mean?

- L means lecture
- E means exercises
- P means practical lab course

## What does 2/2/0 or 4/4/1 mean?

The **first number** stands for the hours per week for the **lecture**.
The **second number** stands for the hours per week for the **exercise**.
The **third number** stands for the hours per week for the **practical lab course**.

**Examples:**
2/2/0 = 2 hours per week lectures (90 minutes lecture every week), 2 hours per week exercises (90 minutes exercises every week), no practical lab course

4/1/1 = 4 hours per week lectures (180 minutes lecture every week), 1 hour (45 minutes) per week exercises but mostly conducted as 90 minutes every other week, 1 hour (45 minutes) per week practical lab course but conducted as 90 minutes every other week or as block course.

## What does "PL" mean"?

It is German for Prüfungsleistung which means assessment.

## I have chosen a module – what to do next?

After you have chosen a module you should know which parts are included in the module, in which semester the parts take place, and if a lecture, tutorial and/or practical lab course is included. Furthermore you should search for it in the timetables.

Detailed information you can find on the websites Plan your Studies as well as
Create your timetable.

**Note: The English version of our module descriptions is not legally binding.**

# Overview of the
# Basic studies modules 1st-4th semester (Bachelor level)

| **Module number, with link to description** | **Module name**<br>English<br>German | **1st semester winter**<br>L/T/P | **2nd semester summer**<br>L/T/P | **3rd semester winter**<br>L/T/P | **4th semester summer**<br>L/T/P | **Language of instruction** | **ECTS Credits** |
|---|---|---|---|---|---|---|---|
| EuI-ET-C-GET | Basics of Electrical Engineering<br>Grundlagen der Elektrotechnik | 2/2/0<br>PL | | | | German | **5** |
| EuI-IST-C-Ma1 | Introduction to Analysis and Algebra<br>Algebraische und analytische Grundlagen | 6/4/0<br>PL | | | | German | **11** |
| INF-IST-C-Prg | Programming and RoboLab<br>Programmierung und RoboLab | 2/2/4<br>2 PL | | | | German | **9** |
| INF-IST-C-AuD | Algorithms and Data Structures<br>Algorithmen und Datenstrukturen | | 2/2/0<br>PL | | | German | **6** |
| Ma-IST-C-DiStr | Discrete Structures<br>Diskrete Strukturen | | 3/2/0<br>PL | | | German | **6** |
| EuI-IST-C-EMF | Electric and Magnetic Fields<br>Elektrische und magnetische Felder | | 2/2/0<br>PL | | | German | **5** |
| EuI-IST-C-Ma2 | Calculus for Functions with Several Variables<br>Mehrdimensionale Differential- und Integralrechnung | | 4/4/0<br>PL | | | German | **9** |
| INF-IST-C-SWT | Software Technology<br>Softwaretechnologie | | 2/2/0<br>PL | | | German | **5** |
| EuI-IST-C-DNW | Dynamical Electrical Networks<br>Dynamische Netzwerke | | | 2/2/0<br>PL | | German | **5** |
| EuI-IST-C-Ma3 | Complex Function Theory<br>Funktionentheorie | | | 2/2/0<br>PL | | German | **5** |
| INF-IST-C-SWTP | Software Technology Project<br>Softwaretechnologie-Projekt | | | 0/0/4<br>PL | | German | **6** |
| EuI-IST-C-TeBE | Microelectronic Technologies and Devices<br>Technologien und Bauelemente der Mikro-elektronik | | | 5/1/0<br>PL | | German | **7** |

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|---|---|---|---|---|---|---|---|
| EuI-IST-C-PraET | Practice Electrical Engineering<br>Praktische Elektrotechnik | | | 0/0/1 | 0/0/2<br>PL | German | **3**<br>**(1+2)** |
| EuI-ET-C-SysTh | Systems Theory<br>Systemtheorie | | | 2/2/0 | 2/2/0<br>PL | German | **9**<br>**(4+5)** |
| INF-IST-C-RA | Computer Architecture and Hardware Lab<br>Rechnerarchitektur und Hardwarelabor | | | | 3/2/2<br>2 PL | German | **9** |
| EuI-ET-C-AT | Automation Engineering<br>Automatisierungstechnik | | | | 2/1/1<br>PL | German | **5** |
| EuI-ET-C-Ma4 | Partial Differential Equations and Probability Theory<br>Partielle Differentialgleichungen und Wahrscheinlichkeitstheorie | | | | 2/2/0<br>PL | German | **5** |
| EuI-ET-C-ST | Electronic Circuits<br>Schaltungstechnik | | | | 2/2/0<br>PL | German | **5** |

# Overview of the
# Main studies modules 5th-10th semester
## (relevant for all specialization areas)

| **Module number, with link to description** | **Module name**<br>English<br>German | **5th semester winter**<br>L/T/P | **6th Semester summer**<br>L/T/P | **Language of instruction** | **ECTS Credits** |
|---|---|---|---|---|---|
| ET-12 08 33 | Digital Circuit Design<br>Digitale Schaltungstechnik | 2/1/0<br>PL | | German | **3** |
| INF-B-275 | Theory and Applications of Formal Systems<br>Theorie und Anwendung formaler Systeme | 4/2/0<br>PL | 2/0/0<br>PL | German | **10** |
| INF-B-370 | Databases/Computer Networks<br>Datenbanken und Rechnernetze | | 4/4/0<br>2 PL | German | **10** |
| INF-B-380 | Operating Systems and Security<br>Betriebssysteme und Sicherheit | 4/2/0<br>PL | | German | **7** |
| ET-12 08 18 | Integrated Circuit Design<br>Schaltkreis- und Systementwurf | 2/1/0 | 0/0/2<br>2 PL | German | **7** |
| ET-12 10 27 | Signal Processing and Information Theory<br>Signalverarbeitung und Informationstheorie | 2/1/0<br>PL | 2/2/0<br>PL | German | **7** |
| ET-12 10 24 | Communications<br>Nachrichtentechnik | | 2/1/0<br>PL | German | **3** |

# Overview of the
# Main studies modules 5th-10th semester
# In the specialization area: **Automation, Sensors and Robotics**

| **Module number, with link to description** | **Module name**<br>English<br>German | **6th semester summer**<br>L/T/P | **7th semester winter**<br>L/T/P | **Language of instruction** | **ECTS Credits** |
|---|---|---|---|---|---|
| ET-12 01 10 | Industrial Automation Engineering 1<br>Industrielle Automatisierungstechnik – Basismodul | 3/1/0<br>PL | 0/0/2<br>PL | German | **7** |
| ET-12 01 21 | Project Planning for Process Automation Systems<br>Projektierung von Automatisierungssystemen | 2/2/2<br>2 PL | | German/ English | **7** |
| ET-12 01 11 | Industrial Automation Engineering 2<br>Industrielle Automatisierungstechnik – Aufbaumodul | 3/2/1<br>2 PL | | German/ English | **7** |
| ET-12 01 12 | Robotics<br>Robotik | 2/1/0<br>PL | 2/1/1<br>2 PL | German | **7** |
| ET-12 01 13 | Systems Design<br>Systementwurf | | 4/2/0<br>2 PL | German | **7** |
| ET-12 13 11 | Nonlinear Control Systems, Advanced<br>Nichtlineare Regelungssysteme – Vertiefung | 2/0/0<br>PL | 2/1/0<br>PL | German | **7** |
| ET-12 13 12 | Optimal and Robust Multivariable Control Systems<br>Optimale, robuste und Mehrgrößenregelung | 2/0/0<br>PL | 2/1/0<br>PL | German | **7** |
| ET-12 01 20 | Human Machine System Technology<br>Mensch-Maschine-Systemtechnik | | 2/2/2<br>2 PL | German | **7** |
| ET-12 01 22 | Process Simulation and Operation<br>Prozessführungssysteme | 1/1/0<br>PL | 2/2/0<br>2 PL | German | **7** |
| IST-W-22-DLMST | Digital Laser Measurement System Technology<br>Digitale Lasermesssystemtechnik | 2/1/1<br>PL | 1/1/1<br>PL | German | **7** |

# Overview of the
# Main studies modules 5th-10th semester
# In the specialization area: **Electronic Circuits and Systems**

| **Module number, with link to description** | **Module name**<br>English<br>German | **6th semester summer**<br>L/T/P | **7th semester winter**<br>L/T/P | **Language of instruction** | **ECTS Credits** |
|---|---|---|---|---|---|
| ET-12 08 19 | VLSI Processor Design<br>VLSI-Prozessorentwurf | 2/2/2<br>2 PL | | English | **7** |
| ET-12 08 16 | Radio Frequency Integrated Circuits | 3/1/2<br>PL | | English | **7** |
| ET-12 08 17 | Integrated Circuits for Broadband Optical Communications | | 3/1/2<br>PL | English | **7** |
| ET-12 10 16 | Digital Signal Processing and Hardware Implementation<br>Digitale Signalverarbeitung und Hardware-Implementierung | 2/1/2<br>2 PL | | English | **7** |
| ET-12 08 08 | Circuit Simulation and System Identification<br>Schaltungssimulation und Systemidentifikation | 1/1/0<br>PL | 2/1/0<br>PL | German | **7** |
| ET-12 08 27 | Neuromorphic VLSI Systems<br>Neuromorphe VLSI Systeme | 4/2/0<br>2 PL | | German | **7** |
| EuI-IST-E-ICDBS | Integrated Circuit Design for Biomedical Sensors | 2/0/2<br>2 PL | | English | **7** |

# Overview of the
# Main studies modules 5th-10th semester
# In the specialization area: **Communication**

| **Module number, with link to description** | **Module name**<br>English<br>German | **6th semester summer**<br>L/T/P | **7th semester winter**<br>L/T/P | **Language of instruction** | **ECTS Credits** |
|---|---|---|---|---|---|
| ET-12 09 08 | Room Acoustics/ Virtual Reality<br>Raumakustik/ Virtuelle Realität | 4/0/2<br>2 PL | | German | **7** |
| ET-12 10 05 | Communication Networks, Advanced I<br>Kommunikationsnetze, Aufbaumodul | 4/2/0<br>2 PL | | German | **7** |
| ET-12 10 09 | Information Theory, Advanced I<br>Aufbaumodul Informationstheorie | | 4/2/0<br>2 PL | German or English | **7** |
| ET-12 10 21 | Network Coding: Theory and Practice<br>Netzwerkkodierung in Theorie und Praxis | 4/2/0<br>2 PL | | German or English | **7** |
| ET-12 10 16 | Digital Signal Processing and Hardware Implementation<br>Digitale Signalverarbeitung und Hardware-Implementierung | 2/1/2<br>2 PL | | English | **7** |
| ET-12 09 13 | Applied Intelligent Signal Processing<br>Angewandte intelligente Signalverarbeitung | 4/1/1<br>PL | | German or English | **7** |
| ET-12 09 04 | Speech Technology<br>Sprachtechnologie | | 4/0/2<br>PL | German or English | **7** |
| ET-12 09 09 | Psychoacoustics/ Sound Design<br>Psychoakustik/ Sound Design | | 4/2/0<br>2 PL | German | **7** |
| ET-12 10 20 | Communication Networks, Advanced II (Communication Networks 3)<br>Kommunikationsnetze, Vertiefungsmodul | | 4/2/0<br>2 PL | English | **7** |
| ET-12 10 22 | Intelligent and cooperative Communications<br>Intelligente und kooperative Kommunikation | 4/2/0<br>2 PL | | German or English | **7** |
| ET-12 10 19 | Optimization in modern Communication Systems<br>Optimierung in modernen Kommunikationssystemen | | 4/2/0<br>2 PL | German or English | **7** |
| ET-12 10 13 | RF Systems<br>Hochfrequenzsysteme | 4/2/0<br>PL | | German | **7** |

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|---|---|---|---|---|---|
| ET-12 10 15 | Basics Mobile Communications Systems<br>Grundlagen mobiler Nachrichtensysteme | 4/2/0<br>PL | | German | **7** |
| ET-12 10 17 | Upgrade Mobile Communication Systems<br>Vertiefung Mobile Nachrichtensysteme | | 4/2/0<br>PL | English | **7** |
| ET-12 10 18 | Digital Signal Processing Systems<br>Digitale Signalverarbeitungssysteme | | 3/1/2<br>2 PL | German | **7** |
| NES-12 10 08 | Introduction to Optical Non-classical Computing: Concepts and Devices | 4/2/0<br>2 PL | | English | **7** |

# Overview of the
# Main studies modules 5th-10th semester
# In the specialization area: **Microelectronics**

| **Module number, with link to description** | **Module name**<br>English<br>German | **6th semester summer**<br>L/T/P | **7th semester winter**<br>L/T/P | **Language of instruction** | **ECTS Credits** |
|---|---|---|---|---|---|
| ET-12 12 02 | Design of Microelectromechanical Systems<br>Entwurf Mikroelektromechanischer Systeme | 4/2/0<br>2 PL | | German | **7** |
| ET-12 05 09 | Electronic Design Automation<br>Entwurfsautomatisierung | | 2/4/0<br>2 PL | German | **7** |
| ET-12 06 07 | Hybrid Integration<br>Hybridintegration | | 4/0/2<br>3 d excur-sion<br>2 PL | German/<br>English | **7** |
| ET-12 08 19 | VLSI Processor Design<br>VLSI-Prozessorentwurf | | 2/2/2<br>2 PL | English | **7** |
| ET-12 11 04 | Sensors and Sensor Systems<br>Sensoren und Sensorsysteme | | 4/1/1<br>2 PL | German | **7** |
| ET-12 12 04 | Memory Technology | 2/1/0 | 2/1/0<br>PL | English | **7** |
| ET- 12 11 05 | Plasma Technology<br>Plasmatechnik | | 4/2/0<br>PL | English | **7** |
| NES-22-E-NNMHA | Neural Networks and Memristive Hardware Accelerators | | 2/0/2<br>2 PL | English | **7** |

# Overview of the
# Main studies modules 5th-10th semester
# In the specialization area: **Computer Science**

| **Module number, with link to description** | **Module name** English | **7th semester winter** L/T/P | **8th semester summer** L/T/P | **Language of instruction** | **ECTS Credits** |
|---|---|---|---|---|---|
| INF-IST-E-SFT.Lab | Software Fault Tolerance Lab | 0/0/4 PL | | English | **6** |
| INF-IST-E-SFT | Software Fault Tolerance | | 2/2/0 PL | English | **6** |
| INF-IST-E-RNA | Advanced Computer Networks | 2/2/0 PL | | German or English | **6** |
| INF-IST-E-Dec | Decentralized Systems | 2/2/0 2 PL | | German or English | **6** |
| INF-IST-E-DS | Distributed Systems | 2/2/0 PL | | English | **6** |
| INF-IST-E-EAMA | Engineering Adaptive Mobile Applications | 2/2/0 PL | | English | **6** |
| INF-IST-E-IM | Internet Measurements | 2/2/0 2 PL | | English | **6** |
| INF-IST-E-IoT | IoT Communication | 2/2/0 2 PL | | German or English | **6** |
| INF-IST-E-MOS | Microkernel-Based Operating Systems | 2/4/0 PL | | English | **6** |
| INF-IST-E-PrET | Prediction and Estimation Techniques | 2/2/0 PL | | English | **6** |
| INF-IST-E-SDE | Scalable Data Engineering | 2/2/0 PL | | German or English | **6** |
| INF-IST-E-SDM | Scalable Data Management | 2/2/0 PL | | English | **6** |
| INF-IST-E-SCC | Service and Cloud Computing | 2/2/0 PL | | English | **6** |

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|---|---|---|---|---|---|
| INF-IST-E-SE | Systems Engineering | 2/2/0<br>PL | | English | **6** |
| INF-IST-E-CPSM.Lab1 | Cyber Physical Systems Modeling Lab | 0/0/4<br>PL | | German or English | **6** |
| INF-IST-E-EMIN | Engineering and Management of Industrial Networks | 3/1/0<br>PL | | German or English | **6** |
| INF-IST-E-CPS | Foundations of Cyber Physical Systems | 2/2/0<br>PL | | German or English | **6** |
| INF-IST-E-IIoT | Industrial Internet of Things | 2/0/2<br>PL | | German or English | **6** |
| INF-IST-E-CPSM.Lab2 | Cyber Physical Systems Modeling Lab Advanced | | 0/0/4<br>PL | German or English | **6** |
| INF-IST-E-CRC | Computer and Robot-Assisted Surgery | 2/2/0<br>PL | | English | **6** |
| INF-IST-E-CV | Computer Vision | 2/2/0<br>4 days à 5 hours project<br>PL | | English | **6** |
| INF-IST-E-FDV | Foundations of Data Visualisation | 2/2/0<br>PL | | English | **6** |
| INF-IST-E-FVR | Foundations of Virtual Reality | 2/2/0<br>PL | | English | **6** |
| INF-IST-E-ML | Machine Learning | 2/2/0<br>4 days à 5 hours project<br>PL | | English | **6** |
| INF-IST-E-EPA | Efficient Parallel Algorithms | 2/2/0<br>PL | | German | **6** |
| INF-IST-E-HMS | Hardware Modeling and Simulation | 2/2/0<br>PL | | English | **6** |
| INF-IST-E-HPC | High Performance Computing | 2/2/0<br>PL | | German or English | **6** |
| INF-IST-E-HPGPU | Highly Parallel Programming of GPUs | 2/1/1<br>PL | | German or English | **6** |

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|---|---|---|---|---|---|
| INF-IST-E-ETI | Introduction to Computer Engineering | 4/2/2<br>PL | | German or English | **12** |
| INF-IST-E-PACS | Performance Analysis of Computing Systems | 2/2/0<br>PL | | English | **6** |
| INF-IST-E-ADS.Lab | Adaptive Dynamic Systems Lab | 0/0/4<br>PL<br>*offered each semester* | 0/0/4<br>PL<br>*offered each semester* | English | **6** |

# Module descriptions
# Basic studies modules 1st-4th semester

| | |
|---|---|
| Module name | **Basics of Electrical Engineering** |
| Module number | EuI-IST-C-GET<br>(EuI-BMT-C-GET, EuI-ET-C-GET, EuI-MT-C-GET, EuI-RES-C-GET) |
| Lecturer in charge | Prof. Dr. phil. nat. habil. Ronald Tetzlaff<br>ronald.tetzlaff@tu-dresden.de |
| Objectives | After completing the module, students have basic knowledge of electrical engineering and electronics and have mastered methods for solving electrical engineering problems as a basis for further modules. The focus is on resistive circuits. They are able to describe linear and non-linear two-pole circuits and take into account the temperature dependence of their parameters, systematically analyze electrical circuits with direct current and apply special simplified analysis methods such as two-pole theory and the superposition theorem. They can calculate the power conversion in circuits and analyze and measure thermal arrangements. |
| Contents | The content of the module is the calculation of electrical networks with direct current. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. |
| Prerequisites | Knowledge of mathematics and physics at basic A-level is required. |
| Usability | The module is a compulsory module in the basic studies of the degree programmes Electrical Engineering, Biomedical Engineering, Information Systems Engineering, Mechatronics and Renewable Energy Systems.<br>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 150 minutes. |
| Credit points and grades | 5 credit points can be obtained by the module. The module grade is the grade of the examination. |
| Frequency | The module is offered every winter semester. |
| Workload | The total effort is 150 hours. |
| Duration | The module takes one semester. |

| | |
|---|---|
| Module name | **Introduction to Analysis and Algebra** |
| Module number | EuI-IST-C-Ma1<br>(EuI-BMT-C-Ma1, EuI-ET-C-Ma1, EuI-MT-C-Ma1, EuI-RES-C-Ma1) |
| Lecturer in charge | Prof. PD Dr. Sebastian Franz<br>sebastian.franz@tu-dresden.de |
| Objectives | After completing the module, students have basic mathematical knowledge and knowledge of algebra. They are able to calculate with real and complex numbers and apply functions, sequences, series, vectors, vector spaces, determinants and matrices. |
| Contents | The contents of the module are set theory, real and complex numbers, number sequences, series, analysis of real functions of one variable, linear spaces and mappings, matrices, determinants, linear sliding systems, eigenvalues and eigenvectors. |
| Modes of teaching and learning | 6 hours per week lectures, 4 hours per week exercises and self-study. |
| Prerequisites | Knowledge of mathematics at basic A-level is required. |
| Usability | The module is a compulsory module in the basic studies of the degree programmes Electrical Engineering, Biomedical Engineering, Information Systems Engineering, Mechatronics and Renewable Energy Systems.<br>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. |
| Credit points and grades | 11 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 330 hours. |
| Duration | The module takes one semester. |

| | |
|---|---|
| Module name | **Programming and RoboLab** |
| Module number | INF-IST-C-Prg |
| Lecturer in charge | Prof. Dr. Christof Fetzer<br>christof.fetzer@tu-dresden.de |
| Objectives | After completing the module, students are familiar with the structure and functioning of programming languages, have programming skills, and can apply these in a practical manner. They are able to solve problems independently, learn additional programming languages on their own, and transfer their skills to these languages. They can analyze and evaluate programming languages. This enables them to analyze and evaluate programming languages in order to select the appropriate language for solving various problems. Students acquire skills in solving complex tasks within a team. |
| Contents | The module covers the use and development of formal tools, the fundamentals of computation, translation of program constructors, program transformations, and the verification of program properties. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises, 4 hours per week practical lab courses and self-study. |
| Prerequisites | Mathematical knowledge at basic A-level are required. |
| Usability | The module is a compulsory module in the basic studies of the degree programme Information Systems Engineering.<br>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 80 hours. Both exam components are relevant to passing the module. Bonus points for the exam can be earned by completing 15 hours of practice exercises. |
| Credit points and grades | 9 credit points can be obtained by the module. The module grade is the unweighted mean of the examinations. |
| Frequency | The module is offered every winter semester. |
| Workload | The total effort is 270 hours. |
| Duration | The module takes one semester. |

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|---|---|
| Module name | **Algorithms and Data Structures** |
| Module number | INF-IST-C-AuD |
| Lecturer in charge | Holder of the Chair of Algorithms |
| Objectives | After completing the module, students will be familiar with important algorithmic problems and the basic approaches to solving these problems. They will be able to translate these approaches into concrete algorithms using suitable data structures and analyze their formal properties. |
| Contents | The module covers sorting and searching problems as algorithmic questions, as well as problems involving graphs and trees, approaches to divide-and-conquer methods, dynamic programming, recursion, backtracking, and various methods for the formal analysis of algorithm complexity. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. |
| Prerequisites | The skills to be acquired in the modules **Introduction to Analysis and Algebra** and **Programming and RoboLab** are required. |
| Usability | The module is a compulsory module in the basic studies of the degree programme Information Systems Engineering.<br>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 examination. |
| Frequency | The module is offered every summer semester. |
| Workload | The total effort is 180 hours. |
| Duration | The module takes one semester. |

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| Module name | **Discrete Structures** |
| Module number | Ma-IST-C-DiStr |
| Lecturer in charge | Prof. Dr. Ulrike Baumann<br>ulrike.baumann@tu-dresden.de |
| Objectives | After completing the module, students are familiar with basic mathematical concepts, notation, and forms of argumentation using the example of set and formula language and elements of discrete mathematics. They are familiar with the basic concepts of the aforementioned areas of theory and can confidently apply them in a mathematical context. In particular, they can formulate and prove facts from the aforementioned fields of knowledge mathematically correctly. Students are able to relate the theoretical elements they have studied to applied questions in a meaningful way and solve problems. |
| Contents | The module covers mathematics as a theoretical language and tool of computer science, as well as elements of discrete mathematics. Specifically, the content includes sets, relations (in particular equivalence and order relations), mappings, Boolean functions and propositional logic, natural numbers, proofs using complete induction and modular arithmetic, the fundamentals of graph theory, and the applications of these concepts in computer science. |
| Modes of teaching and learning | 3 hours per week lectures, 2 hours per week exercises and self-study. |
| Prerequisites | The skills to be acquired in the modules **Introduction to Analysis and Algebra** are required. |
| Usability | The module is a compulsory module in the basic studies of the degree programme Information Systems Engineering.<br>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 examination. |
| Frequency | The module is offered every summer semester. |
| Workload | The total effort is 180 hours. |
| Duration | The module takes one semester. |

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| Module name | **Electric and Magnetic Fields** |
| Module number | EuI-IST-C-EMF<br>(EuI-BMT-C-EMF, EuI-ET-C-EMF, EuI-MT-C-EMF, EuI-RES-C-EMF) |
| Lecturer in charge | Prof. Dr. phil. nat. habil. Ronald Tetzlaff<br>ronald.tetzlaff@tu-dresden.de |
| Objectives | After completing the module, students know the basic concepts, quantities and methods for calculating simple electric fields and magnetic fields. They are able to calculate the energy stored in the field, the force effects caused by the fields and the induction effects in the magnetic field. Students are familiar with the basic principles of the electronic components resistor, capacitor, coil and transformer and their descriptive equations. |
| Contents | The module covers the calculation of simple electric fields and magnetic fields. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. |
| Prerequisites | The skills to be acquired in the modules **Introduction to Analysis and Algebra** and **Basics of Electrical Engineering** are required. |
| Usability | The module is a compulsory module in the basic studies of the degree programmes Electrical Engineering, Biomedical Engineering, Information Systems Engineering, Mechatronics and Renewable Energy Systems.<br>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 150 minutes. |
| Credit points and grades | 5 credit points can be obtained by the module. The module grade is the grade of the examination. |
| Frequency | The module is offered every summer semester. |
| Workload | The total effort is 150 hours. |
| Duration | The module takes one semester. |

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| Module name | **Calculus for Functions with Several Variables** |
| Module number | EuI-IST-C-Ma2<br>(EuI-BMT-C-Ma2, EuI-ET-C-Ma2, EuI-MT-C-Ma2, EuI-RES-C-Ma2) |
| Lecturer in charge | Prof. PD Dr. Sebastian Franz<br>sebastian.franz@tu-dresden.de |
| Objectives | After completing the module, students have knowledge of differentiation and integration of functions with one and several variables, analytical solutions of differential equations and systems of differential equations as well as vector analysis. |
| Contents | The contents of the module are analysis of real functions of several variables, vector analysis, function series, differential equations and Taylor series. |
| Modes of teaching and learning | 4 hours per week lectures, 4 hours per week exercises and self-study. |
| Prerequisites | The skills to be acquired in the modules **Introduction to Analysis and Algebra** are required. |
| Usability | The module is a compulsory module in the basic studies of the degree programmes Electrical Engineering, Biomedical Engineering, Information Systems Engineering, Mechatronics and Renewable Energy Systems.<br>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 150 minutes. |
| 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 summer semester. |
| Workload | The total effort is 270 hours. |
| Duration | The module takes one semester. |

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| Module name | **Software Technology** |
| Module number | INF-IST-C-SWT<br>(INF-MT-E-SWT) |
| Lecturer in charge | Prof. Dr. Uwe Aßmann<br>uwe.assmann@tu-dresden.de |
| Objectives | After completing the module, students know the methods for developing software systems. They are able to apply a systematic engineering-technical approach using the concepts of object orientation and to apply object-oriented modeling and programming languages in analysis, design and implementation. |
| Contents | The contents of the module are the introduction to an object-oriented modeling language such as the Unified Modeling Language (UML) as well as reuse aspects in an object-oriented programming language such as Java, with particular emphasis on the use of class libraries and design patterns. The module also includes an introduction to object-oriented analysis, design and architecture. Basic information on project management, agile software development and software quality assurance round off the content. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. |
| Prerequisites | In the Diploma programme Information Systems Engineering the skills acquired in the modules **RoboLab** and **Algorithms and Data Structures**, in particular the programming of class structures and procedures, are required.<br>In the Diploma programme Mechatronics skills acquired in the modules<br>**Software Engineering Basics** and **Software Engineering Advanced** are required. |
| Usability | The module is a compulsory module in the basic studies of the degree programme Information Systems Engineering. Further, it is a compulsory elective module from the compulsory elective area Methods and Applications according to § 6 paragraph 3 SO and § 33 paragraph 3 PO of the main course of study in the Diploma degree programme Mechatronics.<br>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 15 hours of exercises. |
| Credit points and grades | 5 credit points can be obtained by the module. The module grade is the grade of the examination. |

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

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| Module name | **Dynamical Electrical Networks** |
| Module number | EuI-IST-C-DNW<br>(EuI-BMT-C-DNW, EuI-ET-C-DNW, EuI-MT-C-DNW, EuI-RES-C-DNW) |
| Lecturer in charge | Prof. Dr. phil. nat. habil. Ronald Tetzlaff<br>ronald.tetzlaff@tu-dresden.de |
| Objectives | After completing the module, students will know methods for analyzing linear dynamic circuits when excited with periodic signals or in the transition behavior of stationary states. They are able to describe, model and calculate linear two-ports. They can determine the transfer function, analyze and graphically represent the behavior in the frequency range and calculate simple filters. They will know pointer representations and locus curves. |
| Contents | The content of the module is the calculation of linear dynamic networks. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. |
| Prerequisites | The skills to be acquired in the modules **Basics of Electrical Engineering, Calculus for Functions with Several Variables** and **Electric and Magnetic Fields** are required. |
| Usability | The module is a compulsory module in the basic studies of the degree programmes Electrical Engineering, Biomedical Engineering, Information Systems Engineering, Mechatronics and Renewable Energy Systems.<br>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 150 minutes. |
| Credit points and grades | 5 credit points can be obtained by the module. The module grade is the grade of the examination. |
| Frequency | The module is offered every winter semester. |
| Workload | The total effort is 150 hours. |
| Duration | The module takes one semester. |

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| Module name | **Complex Function Theory** |
| Module number | EuI-IST-C-Ma3<br>(EuI-ET-C-Ma3, EuI-BMT-C-Ma3, EuI-MT-C-Ma3, EuI-RES-C-Ma3) |
| Lecturer in charge | Prof. PD Dr. Sebastian Franz<br>sebastian.franz@tu-dresden.de |
| Objectives | After completing the module, students have knowledge of functions with complex variables. |
| Contents | The content of the module is function theory with a focus on differentiability, integration and series expansion. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. |
| Prerequisites | The skills to be acquired in the modules **Calculus for Functions with Several Variables** are required. |
| Usability | The module is a compulsory module in the basic studies of the degree programmes Electrical Engineering, Biomedical Engineering, Information Systems Engineering, Mechatronics and Renewable Energy Systems.<br>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 examination. |
| Frequency | The module is offered every winter semester. |
| Workload | The total effort is 150 hours. |
| Duration | The module takes one semester. |

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| Module name | **Software Technology Project** |
| Module number | INF-IST-C-SWTP<br>(INF-MT-E-SWTP) |
| Lecturer in charge | Prof. Dr. Uwe Aßmann<br>uwe.assmann@tu-dresden.de |
| Objectives | After completing the module, students have practical engineering skills in the implementation of team-oriented, work-sharing software projects. Students are able to work with a customer to analyze their requirements and to design, implement and test a software system and have it accepted by the customer. |
| Contents | The content of the module is the implementation of a team-oriented software development process that records and processes customer requirements. This includes the application to be realized for the customer, the creation of a requirements specification, a software design and small prototypes for familiarization with the frameworks or technologies to be used, as well as implementation and documentation. Further content includes quality assurance, such as the creation of a test suite and the evaluation of software analyses. The module also includes project management activities such as group meetings and their minutes, customer meetings, recording working hours, reflection and controlling of the project status at well-defined milestones and a final presentation to the customer. |
| Modes of teaching and learning | 4 hours per week practical lab courses and and self-study. |
| Prerequisites | The skills to be acquired in the module **Software Technology** are required. This includes, in particular, methods for developing large software systems, object orientation, the use of a modeling language such as the Unified Modeling Language (UML) in analysis, design and implementation as well as programming in an object-oriented programming language such as Java. |
| Usability | The module is a compulsory module in the basic studies of the degree programme Information Sytems. Further, it is a compulsory elective module from the compulsory elective area of Methods and Applications of the main course of study in the Diploma degree programme Mechatronics in accordance with § 6 section 3 of the study regulations and § 33 section 3 of the exam regulations.<br>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 ungraded complex assignment of of 100 hours. |
| Credit points and grades | 6 credit points can be obtained by the module. The module is assessed as “passed” or “failed”. |

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| Frequency | The module is offered every winter semester. |
| Workload | The total effort is 180 hours. |
| Duration | The module takes one semester. |

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| Module name | **Microelectronic Technologies and Devices** |
| Module number | EuI-IST-C-TeBE |
| Lecturer in charge | Prof. Dr.-Ing. habil. Michael Schröter<br>michael.schroeter@tu-dresden.de |
| Objectives | After completing the module, students will be able to understand the basic functioning and electrical properties of the most important semiconductor components based on a simplified description of the physical potential relationships and transport mechanisms in semi-conductors, to discuss the most important characteristic curves, to construct physical model descriptions - including equivalent circuit diagrams - of semiconductor components for their applications, to work with basic principles for the manufacture and miniaturization of components and circuits and to understand the modes of action of the individual technologies and their interaction to form simple process sequences. |
| Contents | The module covers the physical principles of electronic components and the physical and technical principles of their manufacture using microtechnologies. |
| Modes of teaching and learning | 5 hours per week lectures, 1 hours per week exercises and self-study. |
| Prerequisites | The skills to be acquired in the module **Introduction to Analysis and Algebra, Basics of Electrical Engineering, Materials Science** and **Physics** are required. |
| Usability | The module is a compulsory module in the basic studies of the degree programme Electrical Engineering.<br>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 210 minutes. |
| Credit points and grades | 7 credit points can be obtained by the module. The module grade is the grade of the examination. |
| Frequency | The module is offered every winter semester. |
| Workload | The total effort is 210 hours. |
| Duration | The module takes one semester. |

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| Module name | **Practice Electrical Engineering** |
| Module number | EuI-IST-C-PraET<br>(EuI-ET-C-PraET, EuI-MT-C-PraET) |
| Lecturer in charge | Prof. Dr. phil. nat. habil. Ronald Tetzlaff<br>ronald.tetzlaff@tu-dresden.de |
| Objectives | After completing the module, students are familiar with the use of electronic measuring devices. They have extensive skills and experience in setting up and carrying out experiments, evaluating and presenting test and measurement results, assessing measurement methods and measurement uncertainties and writing protocols. |
| Contents | The module covers measurements on electronic circuits, including computer-controlled measurement technology. |
| Modes of teaching and learning | 3 hours per week practical lab courses and and self-study. |
| Prerequisites | The skills to be acquired in the modules **Basics of Electrical Engineering, Introduction to Analysis and Algebra, Calculus for Functions with Several Variables** and **Electric and Magnetic Fields** are required. |
| Usability | The module is a compulsory module in the basic studies of the degree programmes Electrical Engineering, Information Systems Engineering and Mechatronics.<br>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 assignment of 33 hours. |
| Credit points and grades | 3 credit points can be obtained by the module. The module grade is the grade of the examination. |
| Frequency | The module is offered every academic year beginning in the winter semester. |
| Workload | The total effort is 90 hours. |
| Duration | The module takes two semesters. |

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| Module name | **Computer Architecture and Hardware Lab** |
| Module number | INF-IST-C-RA |
| Lecturer in charge | Dr. Robert Schöne<br>robert.schoene@tu-dresden.de |
| Objectives | After completing the module, students have a basic understanding of the structure and functioning of information processing systems and the implementation of simple analog and digital circuits. They have a balanced theoretical and methodological understanding of the structure and organization of computers and their basic components, including an understanding of complex computer systems, the application of parallelism, and performance evaluation. |
| Contents | The module covers the structure and analysis of simple analog and digital circuits, such as RC elements, combinational circuits and flip-flops, sequential and machine-controlled circuits, and the Von Neumann architecture. Other topics include the structure and function of the individual components of a computer structure, their organization, and their interaction. This includes information representation, encoding, and processing; the implementation of switching networks and switching circuits at the gate level; the instruction set as a link to the software; and the components of a computer, such as the control unit, arithmetic unit, registers, and memory; the various types of parallelism, networking, and performance evaluations of complex computer systems. |
| Modes of teaching and learning | 3 hours per week lectures, 2 hours per week exercises, 2 hours per week practical lab courses and self-study. |
| Prerequisites | The skills to be acquired in the module **Basics of Electrical Engineering** are required. |
| Usability | The module is a compulsory module in the basic studies of the degree programmes Information Systems Engineering.<br>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 240 minutes. |
| Credit points and grades | 10 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. |

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| Duration | The module takes two semesters. |

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| Module name | **Systems Theory** |
| Module number | EuI-IST-C-SysTh<br>(EuI-ET-C-SysTh, EuI-MT-C-SysTh) |
| Lecturer in charge | Prof. Dr.-Ing. Rafael F. Schaefer<br>rafael.schaefer@tu-dresden.de |
| Objectives | After completing the module, students will be familiar with the organizing significance of the concept of systems in engineering as well as the general conceptual and methodological foundations for describing dynamic processes in nature and technology. They will be able to view static and dynamic systems from a uniform system-theoretical point of view and describe and analyze them mathematically. They know the properties of continuous-time and discrete-time systems in the time and image domain and are proficient in the use of signal transformations to effectively describe system behavior in the image domain. In particular, they are able to apply systems theory thinking to important areas of their field of study, for example to the calculation of electrical networks with non-sinusoidal or stochastic excitation and to the realization of systems with desired transmission behavior in discrete-time form such as digital filters. |
| Contents | The contents of the module are the basics of system theory with a focus on analog signals and systems with continuous time, analog signals and systems with discrete time, digital systems, stochastic signals and systems as well as selected applications. |
| Modes of teaching and learning | 4 hours per week lectures, 4 hours per week exercises and self-study. |
| Prerequisites | The skills to be acquired in the module **Introduction to Analysis and Algebra, Calculus for Functions with Several Variables** and **Basics of Electrical Engineering** are required. |
| Usability | The module is a compulsory module in the basic studies of the degree programmes Electrical Engineering, Information Systems Engineering and Mechatronics.<br>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 | 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 270 hours. |

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| Duration | The module takes two semesters. |

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| Module name | **Partial Differential Equations and Probability Theory** |
| Module number | EuI-IST-C-Ma4<br>(EuI-BMT-C-Ma4, EuI-ET-C-Ma4, EuI-MT-C-Ma4, EuI-RES-C-Ma4) |
| Lecturer in charge | Prof. PD Dr. Sebastian Franz<br>sebastian.franz@tu-dresden.de |
| Objectives | After completing the module, students will have knowledge of special analytical methods for solving partial differential equations and probability theory. |
| Contents | The module focuses on partial differential equations and probability theory. |
| Modes of teaching and learning | 4 hours per week lectures, 4 hours per week exercises and self-study. |
| Prerequisites | The skills to be acquired in the module **Complex Function Theory** are required. |
| Usability | The module is a compulsory module in the basic studies of the degree programmes Electrical Engineering, Biomedical Engineering, Information Systems Engineering, Mechatronics and Renewable Energy Systems.<br>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 examination. |
| Frequency | The module is offered every summer semester. |
| Workload | The total effort is 150 hours. |
| Duration | The module takes one semester. |

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| Module name | **Automation Engineering** |
| Module number | EuI-IST-C-AT<br>(EuI-ET-C-AT, EuI-MT-C-AT) |
| Lecturer in charge | Prof. Dr. techn. Klaus Janschek<br>klaus.janschek@tu-dresden.de |
| Objectives | After completing the module, students will understand basic forms of behavioral description for technical systems and master the elementary theoretical and computer-aided handling of linear, time-invariant and discrete-event behavioral models for controlling technical systems. They are able to independently design regulation and control algorithms for simple tasks. |
| Contents | The module covers the fundamentals of automation technology with a focus on behavioral description, controller design in the frequency range, digital control loops, standard industrial controllers, discrete-event controllers, elementary control concepts and automation technologies. The module also includes the independent implementation of control algorithms in the form of a practical programming course. |
| Modes of teaching and learning | 2 hours per week lectures, 1 hour per week exercises, 1 hour per week practical lab courses and self-study. |
| Prerequisites | Knowledge of physics at basic A-level is required. |
| Usability | The module is a compulsory module in the basic studies of the degree programmes Electrical Engineering, Information Systems Engineering and Mechatronics.<br>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 60 hours of exercises. |
| Credit points and grades | 5 credit points can be obtained by the module. The module grade is the grade of the examination. |
| Frequency | The module is offered every summer semester. |
| Workload | The total effort is 150 hours. |
| Duration | The module takes one semester. |

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| Module name | **Circuit Design** |
| Module number | EuI-IST-C-ST<br>(EuI-BMT-C-ST, EuI-ET-C-ST, EuI-MT-C-ST, EuI-RES-E-ST) |
| Lecturer in charge | Prof. Dr. sc. techn. habil. Frank Ellinger<br>frank.ellinger@tu-dresden.de |
| Objectives | After completing the module, students will know the basic principles, analysis and dimensioning of basic electronic circuits. From the topologies of the circuits, students can derive their function and calculate their properties. |
| Contents | The contents of the module are the basics of analog and digital electronic circuits using transistors. The following circuits are covered: Basic amplifier circuits, differential amplifiers, operational amplifiers including application examples such as active filters, oscillators, inverters, basics of digital technology, flip-flops, combinatorial switching networks, sequential circuits and analog-to-digital converters. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. |
| Prerequisites | The skills to be acquired in the module **Introduction to Analysis and Algebra** and **Basics of Electrical Engineering** are required. |
| Usability | The module is a compulsory module in the basic studies of the degree programmes Electrical Engineering, Biomedical Engineering, Information Systems Engineering and Mechatronics. Further, it is a compulsory elective module for subject orientation of the main course of study in the Diploma degree programme Renewable Energy Systems in accordance with § 6 section 3 of the study regulations and § 33 section 3 of the exam regulations.<br>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 examination. |
| Frequency | The module is offered every summer semester. |
| Workload | The total effort is 150 hours. |
| Duration | The module takes one semester. |

# Module descriptions
# Main studies modules 5th-10th semester

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 08 33 | Digital Circuit Design | Prof. Dr.-Ing. habil. Ch. G. Mayr |
| **Contents** | The content of the module focuses on the functionalities and basic design principles of digital circuits. Based on knowledge of component models of active semiconductors, the systematic design and analysis of digital and mixed-signal basic circuits is taught. In addition, the module refers to architecture and system concepts of complex digital systems.<br>The module content is based on innovative industrial concepts and questions in the field of VLSI circuit technology and is constantly being updated. Further, the module focuses on special circuit features in nanoscale CMOS technologies, methods to reduce power loss (low-power circuitry), measures to increase processing speed in high-speed circuits and interfaces, and the consideration of statistical influences of manufacturing technologies. | |
| **Objectives** | –Analysis, dimensioning and optimization of digital combinatorial and sequential basic elements based on current semiconductor technologies (CMOS, BiCMOS, etc.)<br>–Design of complex logic functions in the form of arithmetic-logic circuits (e.g. ALUs, shifters, multipliers), state machines (finite state machines), flip-flops and oscillator circuits<br>–Digital architecture and system concepts such as register transfer logic, memory architectures (DRAM, SRAM, EPROM) and mixed-signal circuits (ADC, DAC, interfaces<br>–Design methodology for complex digital and mixed-signal systems (behavioural description, optimization, validation) | |
| **Modes of teaching and learning** | 2 hours per week lectures, 1 hour per week tutorial, and self-study. | |
| **Prerequisites** | Competences acquired in modules such as<br>Basics of Electrical Engineering,<br>Electronic components, System Theorie and Mathematics. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. This assessment is a written exam of 120 minutes. | |
| **ECTS credit points and grades** | 3 ECTS credits can be earned.<br>The module grade is the grade of the exam. | |
| **Frequency** | annually, in the winter semester | |
| **Workload** | 90 hours | |
| **Duration** | 1 Semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| INF-B-275 | Theory and Applications of Formal Systems | Prof. Dr. Franz Baader |
| **Contents and objectives** | Students are enabled to understand formal systems, to develop such systems in different forms of description and to use them in the context of compiler construction for the analysis of programs and code generation.<br>Contents of the module are the theory of formal systems with the areas of formal languages, automata theory and logic as well as compiler construction as a possible application area of formal systems with lexical, syntactic and semantic analysis, automatic parser generation and code generation. | |
| **Modes of teaching and learning** | 6 hours per week lectures, 2 hours per week tutorials, and self-study | |
| **Prerequisites** | Basic knowledge of mathematics (discrete structures, analysis, linear algebra) as well as of algorithms and data structures and programming is required. | |
| **Usability** | This module is a compulsory module in the diploma course of studies in information systems engineering. | |
| **Requirements for the award of ECTS credit points** | The credit points are acquired if the module examination is passed. The module examination consists of two written esxams of 90 minutes (PL1 + PL2) each. | |
| **ECTS credit points and grades** | 10 ECTS credit points<br>The module grade is calculated from the weighted arithmetic mean of the grades according to:<br>¾ PL1, ¼ PL2. | |
| **Frequency** | Annually, starting in the winter semester | |
| **Workload** | 300 hours | |
| **Duration** | 2 semesters | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| INF-B-370 | Databases/ Computer Networks | Prof. Dr. Alexander Schill |
| **Contents and objectives** | Students have knowledge of database theory and are able to solve application problems in practice. The main focus is on the entity relationship model, the relational data model including the design theory of relational databases and the XML data model as well as on the implementation of database systems, error handling and query processing in database systems. Students are able to apply information technology contexts to concrete example networks, develop transmission methods and associated protocols step-by-step and protect them against errors and attacks, analyse and evaluate network technologies and understand Internet protocol mechanisms and distributed system architectures. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 4 hours per week tutorials, and self-study | |
| **Prerequisites** | Prerequisites are a knowledge of mathematics at high school graduation level, the ability to think methodically and the competences to be acquired in the modules<br>Introduction to Analysis and Algebra,<br>Calculus for Functions with Several Variables,<br>Complex Function Theory,<br>Algorithms and data structures,<br>RoboLab,<br>Programming,<br>Software Technology, with regard to the basic concepts, basic algorithms and architectural concepts of computer science. | |
| **Requirements for the award of ECTS credit points** | The credit points are acquired if the module examination is passed. The module examination consists of two 90-minute written examinations. | |
| **ECTS credit points and grades** | 10 ECTS credit points<br>The module grade is calculated from the average of the grades of the individual examination performances. | |
| **Frequency** | Annually, starting in the summer semester | |
| **Workload** | 300 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| INF-B-380 | Operating Systems and Security | Prof. Dr. Hermann Härtig |
| **Contents and objectives** | Students have knowledge of database theory and are able to solve application problems in practice. The main focus is on the entity relationship model, the relational data model including the design theory of relational databases and the XML data model as well as on the implementation of database systems, error handling and query processing in database systems. Students are able to apply information technology contexts to concrete example networks, develop transmission methods and associated protocols step-by-step and protect them against errors and attacks, analyse and evaluate network technologies and understand Internet protocol mechanisms and distributed system architectures. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 2 hours per week tutorials, and self-study | |
| **Prerequisites** | Competences in computer architecture and organization, imperative programming (e.g. C or Java), stochastics (random variables and distribution) and a basic understanding of program verification are expected, as they are described in the modules<br>Introduction to Analysis and Algebra,<br>Calculus for Functions with Several Variables,<br>Complex Function Theory,<br>Algorithms and Data Structures,<br>RoboLab,<br>Programming,<br>Software Technology, and<br>Computer Architecture. | |
| **Requirements for the award of ECTS credit points** | The credit points are acquired if the module examination is passed. The module examination consists a 90-minute written examination. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade corresponds to the grade of the examination paper. | |
| **Frequency** | Annually, starting in the winter semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 10 24 | Communications | Prof. Dr.-Ing. Dr. h. c.<br>G. Fettweis |
| **Course contents and intended learning outcomes** | The module includes:<br>Signal theory (sine waves, Dirac function, convolution, Fourier transform), linear time-invariant systems (transfer function, impulse response), bandpass signals (real and complex up and down mixing of signals, equivalent lowpass signal), analogue modulation (modulation, demodulation, properties of AM, PM, FM), analogue-digital conversion (sampling, signal reconstruction, quantization, sub- and oversampling), digital modulation schemes (modulation methods, matched-filter receiver, bit error probability).<br><br>Outcomes:<br>After completing this module, the students master the basic principles and the practical application of communications engineering. The students will be able to understand the basic signal processing in communications systems and to describe them mathematically. They are familiar with the transmission in base-band and band-pass area and know the basic analogue and digital modulation methods. They understand the impact of noise on the transmission quality for simple analogue and digital transmission scenarios. | |
| **Teaching methods** | 2 hours per week lectures, 1 hour per week tutorial, and self-study. | |
| **Required previous knowledge** | Competences provided in modules such as<br>Introduction to Analysis and Algebra,<br>Calculus for Functions with Several Variables,<br>Complex Function Theory,<br>Systems Theory, or equivalent. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The module assessment consists of a written exam of 120 minutes. | |
| **ECTS credit points and grades** | 3 ECTS credit points<br>The module grade is the grade of the written exam. | |
| **Frequency** | Annually, in the summer semester | |
| **Workload** | 90 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 01 10 | Industrial Automation Engineering 1 | PD Dr.-Ing. Annerose Braune |
| **Contents and objectives** | Content: Automation technology solutions for locally distributed automation systems using current information technologies such as the Internet, XML and model-driven technologies in automation technology<br>Objectives: The students<br>1. are capable of working with basic concepts, protocols and services of the Internet technologies<br>2. have basic experience and skills in dealing with current technologies that are relevant for automation<br>3. are capable of evaluating basic risks and opportunities of the application of modern information technologies<br>4. are capable of solving a managebale application with the learned methods as a small project. | |
| **Modes of teaching and learning** | 3 hours per week lectures, 1 hour per week tutorial, 2 hours per week project, and self-study | |
| **Requirements for the award of credit points** | The credit points are awarded if the module assessment is passed. The module assessment consists of a written exam of 120 minutes (PL1) and a project of 15 weeks (PL2). | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade (M) is determined by the weighted average of PL1 and PL2: M = (4PL1 + 3PL2)/7. | |
| **Frequency** | annually, beginning in the summer semester | |
| **Workload** | 210 hours | |
| **Duration** | 2 semesters | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 01 11 | Industrial Automation Engineering 2 | Prof. Dr. techn. Klaus Janschek |
| **Content and objectives** | Content: Automation technolgy concepts and solutions for selected applications, such as position control for space vehicles, embedded systems, or industrial automation means.<br>Objectives: The students<br>1. are able to design basic concepts, model descriptions and approaches of the respective application domain<br>2. master fundamental solution methods<br>3. are capable of dealing with examples of automation devices. | |
| **Modes of teaching and learning** | 3 hours per week lectures, 2 hours per week tutorial, 1 hour per week project, and self-study | |
| **Prerequisites** | Competences in the field of Automation Engineering. | |
| **Requirements for the award of credit points** | The credit points are awarded if the module assessment is passed. The module assessment consists of a written exam of 120 minutes (PL1) and a project of 15 hours (PL2). | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade M is determined by the weighted average:<br>M = (3 PL1 + 2 PL2) / 5 | |
| **Frequency** | Annually, in the summer semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 01 12 | Robotics | Prof. Dr. techn. Klaus Janschek |
| **Content and objectives** | Content:<br>**1. Control of serial manipulators**<br>– Kinematic fundamentals<br>– Trajectories<br>– Robot dynamics<br>– Position control<br>– Force control<br>**2. Control of mobile robots**<br>– Kinematic fundamentals<br>– Navigation (localization)<br>– Path planning<br>Objectives: The students are capable of<br>1. applying controlled industrial robot systems. They master the theoretical and computational handling of behavior models and algorithms for the controlling of industrial robot systems (manipulators, serial kinematics).<br>2. working with behavioral models for the navigation (position, orientation) and path planning of autonomous mobile robot platforms. They master the basic methodological and algorithmic approaches<br>3. solving a manageable design task with the learned methods as a small project. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 2 hours per week tutorials, 1 hour per week project, and self-study | |
| **Prerequisites** | Competences in the fields of Control of Continuous-Time Processes and Modelling and Simulation. | |
| **Requirements for the award of credit points** | The credit points are awarded if the module assessment is passed. The module assessment consists of two written exams of 120 minutes each and a project of 20 hours. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the weighted mean of the grades for the elements of assessment: The grades for the written exams contribute by 3/7 each and the grade for the project by 1/7. | |
| **Frequency** | Annually, beginning in the summer semester. | |
| **Workload** | 210 hours | |

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|---|---|
| **Duration** | 2 semesters |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 01 13 | Systems Design | Prof. Dr. techn. Klaus Janschek |
| **Content and objectives** | Content:<br>**1. System design of mechatronic systems**<br>- Multi-body dynamics<br>- Mechatronic converter principles<br>- Stochastic behavior analysis<br>- System budgets<br>**2. System design of complex automation systems**<br>- Definition of requirements<br>- Function-oriented behavior modeling<br>- Object-oriented behavioral modeling<br>- Fundamentals of project management<br><br>Objectives: The students are capable of<br>1. applying methods and tools of physically based behavior modeling and analysis (mechatronic systems). They are able to conduct a sound quantitative evaluation of design and optimization.<br>2. working with concepts, methods and tools of abstract behavior modeling and analysis (complex automation systems). They are able to conduct a sound quantitative evaluation of design and optimization. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 2 hours per week tutorials, and self-study | |
| **Prerequisites** | Competences in the field of Control of Continuous-Time Processes and Modelling and Simulation. | |
| **Requirements for the award of credit points** | The credit points are awarded if the module assessment is passed. The module assessment consists of two written exams of 120 minutes each. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the arithmetic mean of both elements of assessment. | |
| **Frequency** | Annually, in the winter semester. | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 01 20 | Human Machine Systems Technology | Prof. Dr.-Ing. habil. Leon Urbas |
| **Content and objectives** | Content: Principles and methods of the human-machine-system to take into account the human factor in the analysis, evaluation and design of complex, interactive technical systems<br>Objectives: The students<br>1. master fundamental methods of the human-machine systems technology for the description, analysis, evaluation and design of dynamic interactive systems.<br>2. are capable of working systematically on domain-specific issues of human-machine interaction. | |
| **Modes of teaching and learning** | 2 hours per week lectures, 2 hours per week tutorial, 2 hours per week practical lab course and self-study | |
| **Prerequisites** | Competences in the fields of Automation Engineering and Process Control. | |
| **Requirements for the award of credit points** | The credit points are awarded if the module assessment is passed. The module assessment consists of a written exam of 120 minutes and a project of 30 hours. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is determined by the weighted average of both elements of assessment. | |
| **Frequency** | annually, in the winter semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 01 21 | Project Planning for Process Automation Systems | Prof. Dr.-Ing. habil. Leon Urbas |
| **Content and objectives** | Content: Methods for Computer Assisted Engineering in Process Automation (CEA-PA) with the following focus:<br>1. computer-aided integrated and life-cycle-wide project planning of process automation systems with e.g. requirements analysis, basic, detail and order engineering, implementation and commissioning, information modeling for integrated engineering systems<br>2. implementation in automation projects<br><br>Objectives: The students<br>1. know the methods and means for computer-aided project planning of complex automation systems from process requirements and<br>2. can implement these in specific domains and application areas or deepen these by means of further computer-based methods. | |
| **Modes of teaching and learning** | 2 hours per week lectures, 2 hours per week tutorial, 2 hours per week project, and self-study.<br>The language of instruction is at least partly English. | |
| **Requirements for the award of credit points** | The credit points are awarded if the module assessment is passed. The module assessment consists of a written exam of 120 minutes in English language and a project of 30 hours.<br>The written exam can be answered in English or German, depending on the student's choice. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is determined by the arithmetic mean of both elements of assessment: M = (PL1 + PL2) / 2 | |
| **Frequency** | annually, in the summer semester | |
| **Workload** | 210 hours | |
| **Duration of the module** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 01 22 | Process Simulation and Operation | Prof. Dr.-Ing. habil. Leon Urbas |
| **Content and objectives** | The module contains knowledge-based methods and algorithms for automated process evaluation, process diagnosis and process control.<br><br>Qualification goals:<br>The students will be able to plan, design, implement and operate complex knowledge-based close-to-process (partially) automated information processing systems. They will be able to combine and use such methods in systems theory and automation terms in order to create complex automation systems. | |
| **Modes of teaching and learning** | 3 hours per week lectures, 3 hours per week tutorial, and self-study<br>The language of instruction is partly English. | |
| **Prerequisites** | Competences acquired in modules such as Process Control. | |
| **Requirements for the award of credit points** | The credit points are awarded if the module assessment is passed. The module assessment consists of a written exam of 90 minutes each, an oral exam of 30 minutes, and a project of 30 hours. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the arithmetic mean of the module assessments. | |
| **Frequency** | annually, beginning in the summer semester | |
| **Workload** | 210 hours | |
| **Duration of the module** | 2 semesters | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 05 09 | Electronic Design Automation | Prof. Dr.-Ing. habil. J. Lienig |
| **Contents and objectives** | This module covers<br>- Relevance of electronic design automation (EDA)<br>- Design styles, design steps, layout design, geometrical fundamentals, etc.<br>- Floorplanning<br>- Partitioning and placement algorithms<br>- Routing algorithms<br>- Methods for compaction and verification<br>- Trends in EDA<br>Intended learning outcomes:<br>Students completing this module have obtained knowledge of algorithms which are used in modern design tools for physical design automation (going from netlist to the final layout). They are thus capable of writing design modules on their own or adapting commercial design tools for specific tasks. | |
| **Modes of teaching and learning** | 2 hours per week lectures, 2 hours per week tutorials, 2 hours per week seminars, and self-study | |
| **Prerequisites** | Students should have knowledge of the basics of electrical engineering. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The module assessment consists of an oral examination of 30 minutes and tutorial assignments. Both elements of assessment must be passed. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is determined by the weighted average of both elements of assessment: M = (3PL1 + 2PL2) / 5 | |
| **Frequency** | annually, during winter semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 06 07 | Hybrid Integration | Prof. Dr.-Ing. habil. Dr. h.c. Karlheinz Bock |
| **Contents and objectives** | This module includes two parts<br>**1. Hybrid technique**<br>(***Hybridtechnik***)<br>- Technologies for the Hybrid technique,<br>- thin film- and thick film technologies,<br>- substrates and pastes,<br>- thermal processes,<br>- single layer and multilayer techniques,<br>- design rules, hybridisation, components, housing<br>- printing, sintering, laser application and trimming<br>- packaging techniques,<br>- functional test,<br>and<br>**2. Micro und nano integration**<br>(***Mikro- und Nano-Integration***)<br>- Micro and nano integration of electronic components,<br>- nano scaling und nano materials,<br>- processes and tools for the nano structuring,<br>- photonic und nano systems, 3D integration<br>The module provides skills in the fields of thin film and thick film technologies, hybrid integration and packaging of such components. The knowledge of micro and nano integration qualifies the students for the solving of innovative tasks in the electronic packaging technology. The students become able to estimate and choose such technologies. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 2 hours per week practical lab courses, up to 3 one-day excursions, and self-study. The language of instruction is partly English. | |
| **Prerequisites** | Competences in the field of electronic packaging technologies as acquired in the module<br>Microelectronic Technologies and Devices. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The module assessment consists of a written exam of 150 minutes and a practical lab course. Both assessments have to be passed. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the weighted average for the written exam (2/3) and the lab course (1/3). | |
| **Frequency** | annually, in the winter semester | |

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| **Workload** | 210 hours |
| **Duration** | 1 semester |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 08 08 | Circuit Simulation and System Identification | Prof. Dr. phil. nat. habil. R. Tetzlaff |
| **Contents and objectives** | The module contents:<br>the mathematical basics of system identification and its practical application, basic system properties, important modeling approaches, methods for parameter identification and essential aspects of signal selection and data conditioning as well as adaptation of model parameters with appropriate algorithms.<br><br>Outcomes:<br>The students can select suitable model approaches based on theoretical considerations (linear/nonlinear, time/frequency domain). They are aware of simplifications made and consider specific boundary conditions for the applied methods. Students are able to define and analyze the set of data available for the identification and to evaluate it in terms of suitability. The students master the application of common methods for system identification and are able to evaluate the result. | |
| **Modes of teaching and learning** | 3 hours per week lectures, 2 hours per week tutorials, and self-study | |
| **Prerequisites** | Competences acquired in modules such as<br>Basics of Electrical Engineering,<br>Circuit Design,<br>Systems Theory,<br>Introduction to Analysis and Algebra,<br>Calculus for Functions with Several Variables. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessement is passed. The assessment consists of two written exams of 120 minutes. | |
| **ECTS credit points and grades** | 7 credit points<br>The module grade is the arithmetic mean of the two exams. | |
| **Frequency** | annually, in the summer semester | |
| **Workload** | 210 hours | |
| **Duration** | 2 semesters | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 12 02 | Design of Microelectromechanical Systems | Prof. Dr.-Ing. habil. U. Marschner |
| **Contents and objectives** | Contents of the module are<br>1. Design of microsystems with modelling and simulation of technological procedures and processes (electrical components, sensors and actuators as well as complete systems)<br>2. Electromechanical networks with electrical, mechanical, magnetic, fluidic (acoustic) and coupled subsystems including their interactions (common circuit diagram and their behaviour simulation with existing circuit simulation software, such as SPICE),<br>3. Combination of network simulation with the method of finite element modelling (complete systems consisting of electrical and non-electrical components)<br>The students have knowledge<br>- he basic model descriptions of technological processes,<br>- for effective design and clear analysis of the dynamic behaviour of electromechanical and electromagnetic systems,<br>- on the function and modelling of reversible converters in sensors and actuators,<br>- the functionality and possible applications of finite element methods and finite difference methods,<br>- for the overall system description using HDL languages. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 2 hours per week tutorials, 1 hour per week Paperwork and self-study. | |
| **Prerequisites** | The competences to be acquired in the modules Materials and Technical Mechanics and Scientific Fundamentals are required. | |
| **Usability** | The module is a compulsory elective module in the field of microelectronics in the diploma course in electrical engineering, in the diploma course in information systems engineering and in the master course in electrical engineering. | |
| **Requirements for the award of ECTS credit points** | The credit points are acquired if the module examination is passed. The module examination consists of a written paper PL1 of 150 minutes duration and a paper PL2. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade M results from the weighted average of the grade of the examination performance: M = (3 PL1 + PL2) / 4. | |
| **Frequency** | Annually, starting in the summer semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET- 12 08 16 | Radio Frequency Integrated Circuits | Prof. Dr. sc. techn. habil. F. Ellinger |
| **Contents and objectives** | The content of the module focuses on:<br>– 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<br>– advantages and challenges of 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 are discussed from circuit design perspective.<br><br>After completion of the module, the students obtain competences regarding<br>– methods for the design of analog high frequency integrated circuits. They know the basic circuits and architectures of the systems.<br>– analysis and optimisation of these circuits,<br>– complete design cycle for high frequency integrated circuits using the Cadance CAD system and are therefore prepared in this field for the requirements in industry and academia,<br>– technical English | |
| **Modes of teaching and learning** | 3 hours per week lectures, 1 hour per week tutorial, 2 hours per week practical lab courses, and self-study.<br>The lecture is given in English. | |
| **Prerequisites** | Students should have basic knowledge of circuit design on Bachelor level. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The module assessment consists of a written exam of 120 minutes. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the grade of the written exam. | |
| **Frequency** | annually, during the summer semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET- 12 08 17 | Integrated Circuits for Broad-band Optical Communications | Prof. Dr. sc. techn. habil. F. Ellinger |
| **Contents and objectives** | Integrated circuits for optical broadband communications, such as transimpedance amplifiers, detector circuits, laser drivers, multiplexers, frequency dividers, oscillators, phase locked loops, synthesizesr and data recovery circuits.<br><br>Students learn the methods of the design of fast integrated circuits and systems for optical broadband communications. They are able to analyse and optimise these circuits. The students know the complete design cycle using the program CADENCE. | |
| **Modes of teaching and learning** | 3 hours per week lectures, 1 hour per week tutorial, 2 hours per week practical lab courses, and self-study.<br>The language of instruction is English. | |
| **Prerequisites** | Competences acquired in modules such as<br>Circuit Design. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The module assessment consists of a written exam of 120 minutes. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the grade of the written exam. | |
| **Frequency** | Annually, in the winter semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 08 18 | Integrated Circuit Design | Prof. Dr.-Ing. habil.<br>C. Mayr |
| **Contents and objectives** | The content of the module includes the basics and methods for development of application-specific digital integrated circuits (ASICs). This involves the transformation of a numeric algorithm into a data-dependency graph, the useage of scheduling and allocation procedures, optimizing regarding the consumption of resources (area, duration) as well as the implementation and functional verification (simulation) of the ASIC.<br><br>After completing the module, the students are enabled to develop the data path (register transfer description) and the control unit (FSM) of a slected numerial algorithm using a data dependency graph. They know the implementation flow, which includes both the automated synthesis of complex blocks based on a hardware description language (eg. Verilog), as well as manually optimized digital data path elements. | |
| **Modes of teaching and learning** | 2 hours per week lectures, 1 hour per week tutorial, 2 hours per week practical lab courses, and self-study | |
| **Prerequisites** | Competences acquired in modules such as<br>Introduction to Analysis and Algebra,<br>Calculus for Functions with Several Variables,<br>Complex Function Theory,<br>Partial Differential Equations and Probability Theory,<br>Basics of Electrical Engineering<br>Microelectronic Technologies and Devices<br>Cicuit Design. | |
| **Requirements for the award of credit points** | The credit points are earned if the module assessment is passed. The module assessment consists of a project report of 40 hours. | |
| **Credit points and grades** | 7 ECTS credit points<br>The module grade is the grade of the project report. | |
| **Frequency** | annually, beginning in the winter semester | |
| **Workload** | 210 hours | |
| **Duration** | 2 semesters | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 10 27 | Signal processing and information theory | Prof. Dr.-Ing. Rafael F. Schaefer<br>rafael.schaefer@tu-dresden.de |
| **Contents and objectives** | The content of the module focuses on the analysis of continuous-time and discrete-time signals in the time and frequency domain, the description and analysis of stochastic signals and processes, and the basics of information theory in the areas of source and channel coding. Students master the basic principles and practical application of signal processing methods in the time and frequency domain. They are familiar with the differences and relationships between the processing of continuous-time and discrete-time signals. They are familiar with the different forms of spectral analysis and are able to decide which form is to be used under which conditions. In particular, they have mastered computer-aided short-term spectral analysis and are familiar with its special features in application. They master the description methods of stochastic signals as realizations of stochastic processes. The students also know the basics of Shannon's information theory and essential information theoretical results (coding theorems). They are familiar with the essential statements and derivations of the maximum possible lossless compression of data (source coding) and the maximum speed of a reliable data transmission (channel coding). They are familiar with the information measures (entropy, transinformation, capacity, etc.) required for analytical considerations, as well as their properties and operational significance, and are able to calculate with these measures with confidence. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 3 hours per week tutorials, and self-study | |
| **Prerequisites** | Knowledge of probability theory and systems theory is required, which can be acquired in the modules<br>Partial Differential Equations and Probability Theory,<br>System Theorie and<br>Automation Engineering, or equivalent. | |
| **Usability** | This module is a compulsory module in the diploma course of studies in Information Systems Engineering. | |
| **Requirements for the award of ECTS credit points** | The credit points are acquired if the module examination is passed. The module examination consists of two written exams PL1 and PL2 of 120 minutes each. Both examinations must be passed. | |

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| **ECTS credit points and grades** | 7 ECTS credit points can be earned.<br>The module grade M results from the arithmetic mean of the grades of the examinations: M = (PL1 + PL2) / 2. |
| **Frequency** | Annually, starting in the winter semester |
| **Workload** | 210 hours |
| **Duration** | 2 semesters |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 08 19 | VLSI Processor Design | Prof. Dr.-Ing. habil. C. Mayr |
| **Contents and objectives** | Content of the module:<br>- Basics, concepts and methods for designing complex digital VLSI-systems<br>- Architectures for highly integrated digital processing systems, with emphasis on user-specific signal processing systems<br>- Methods for the efficient transfer of architectural concepts in the highly integrated implementation of a digital system.<br>- 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), delivering the data for the manufacture of the chip.<br>- Verification of the design on all levels of abstraction (behaviour, implementation) via simulation (functional verification)<br>- Proof of the equivalence of transformation steps via formal verification, i.e. by checking compliance with design rules (signoff-verification)<br>- Training in working together as a design team (division of tasks, definition of interfaces, schedule planning and time management)<br>Objectives:<br>After completion of this module, the students will be able to carry out a complete implementation and verification of a VLSI-System (e.g. a processor with a complexity comparable to an 8051) using industrial design software (Synopsys, Cadence). | |
| **Modes of teaching and learning** | 2 hours per week lectures, 2 hours per week tutorials,<br>2 hours per week practical lab courses, and self-study | |
| **Prerequisites** | Competences acquired in modules such as<br>Basics of Electrical Engineering,<br>Complex Function Theory,<br>Partial Differential Equations and Probability Theory,<br>Circuit Design,<br>Systems Theory, or equivalent. | |
| **Requirements for the award of credit points** | The credit points are earned if the module assessment is passed. The module assessment consists of a project report of 30 hours and an oral presentation of 20 minutes. | |

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| **Credit points and grades** | 7 ECTS credit points<br>The module grade is the weighted average of the grade of the project report and the grade of the oral presentation:<br>M = (2 PL1 + PL2) / 3. |
| **Frequency** | annually, in winter semester |
| **Workload** | 210 hours |
| **Duration** | 1 semester |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 08 19 | VLSI Processor Design | Prof. Dr.-Ing. habil. C. Mayr |
| **Contents and objectives** | Content of the module:<br>- Basics, concepts and methods for designing complex digital VLSI-systems<br>- Architectures for highly integrated digital processing systems, with emphasis on user-specific signal processing systems<br>- Methods for the efficient transfer of architectural concepts in the highly integrated implementation of a digital system.<br>- 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), delivering the data for the manufacture of the chip.<br>- Verification of the design on all levels of abstraction (behaviour, implementation) via simulation (functional verification)<br>- Proof of the equivalence of transformation steps via formal verification, i.e. by checking compliance with design rules (signoff-verification)<br>- Training in working together as a design team (division of tasks, definition of interfaces, schedule planning and time management)<br>Objectives:<br>After completion of this module, the students will be able to carry out a complete implementation and verification of a VLSI-System (e.g. a processor with a complexity comparable to an 8051) using industrial design software (Synopsys, Cadence). | |
| **Modes of teaching and learning** | 2 hours per week lectures, 2 hours per week tutorials,<br>2 hours per week practical lab courses, and self-study | |
| **Prerequisites** | Competences acquired in modules such as<br>Basics of Electrical Engineering,<br>Complex Function Theory,<br>Partial Differential Equations and Probability Theory,<br>Circuit Design,<br>Systems Theory, or equivalent. | |
| **Requirements for the award of credit points** | The credit points are earned if the module assessment is passed. The module assessment consists of a project report of 30 hours and an oral presentation of 20 minutes. | |

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| **Credit points and grades** | 7 ECTS credit points<br>The module grade is the weighted average of the grade of the project report and the grade of the oral presentation:<br>M = (2 PL1 + PL2) / 3. |
| **Frequency** | annually, in winter semester |
| **Workload** | 210 hours |
| **Duration** | 1 semester |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| **IST-W-22-DLMST** | Digital Laser Measurement SystemTechnology | Prof. Dr.-Ing. habil. J. Czarske |
| **Contents and objectives** | The module deals with the basic principles, the theory of computer-aided optical measuring systems. It includes:<br>- laser measurement technology<br>- digital holography and image processing<br>- project laser sensors<br>Objectives:<br>Students will be able to describe laser optical measuring systems and to digitally analyse measured values. | |
| **Modes of teaching and learning** | 3 hours per week lectures, 2 hours per week tutorials, 2 hours per week project and self-study | |
| **Prerequisites** | Competences acquired in modules such as<br>System Theorie and<br>Automation Engineering,<br>or equivalent. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The module assessment consists of an oral exam as individual exam of 30 minutes (PL1) and a project work (PL2) of 12 weeks. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the weighted average of both module assessments according to:<br>M = (5 PL1 + 2 PL2) / 7. | |
| **Frequency** | annually, beginning in the summer semester | |
| **Workload** | 210 hours | |
| **Duration** | 2 semesters | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 09 13 | Applied Intelligent Signal Processing | Prof. Dr.-Ing. P. Birkholz |
| **Contents and objectives** | The content of the module includes:<br>- methods for recording and analyzing audio signals, image signals and biosignals<br>- methods of classification and regression in the field of machine learning<br>- the implementation of selected processes from 1) and 2) on an embedded system | |
| **Modes of teaching and learning** | 4 hours per week lectures, 1 hour per week tutorial, 1 hour per week practical lab course, and self-study.<br>The language of instruction can be either German or English. At the beginning of the teaching period, the lecturer announces the language the module will be taught in. | |
| **Prerequisites** | Competences acquired in modules such as<br>Signal Theory. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The module assessment is a written exam of 150 minutes and an ungraded lab course. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the unweighted mean of the parts of the assessment. | |
| **Frequency** | annually, in the summer semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 09 04 | Speech Technology | Jun.-Prof. Dr.-Ing. P. Birkholz |
| **Contents and objectives** | The module content includes:<br>The algorithms and methods required for the lingual human-machine interaction (speech recognition and speech synthesis).<br>Learning outcomes:<br>Successful students master the latest technologies being used in speech recognition and speech synthesis. They know the basic concepts of linguistics and the hierarchical semiotic system and the structures of natural language. They are able to define it by means of formal languages and grammars and employ this knowledge in the development of speech recognition systems.<br>Furthermore, they know the structure of speech synthesis systems and the algorithms used in linguistic-phonetic and acoustic-phonetic implementations. They know how to adapt these systems to meet specific demands such as multilingual or multimodal interaction. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 2 hours per week practical lab courses, and self-study<br>The language of instruction can be either German or English. At the beginning of the teaching period, the lecturer announces the language the module will be taught in. | |
| **Prerequisites** | Competences acquired in modules such as<br>Signal Theory,<br>ET-12 09 03 Intelligent Audio Signal Processing,<br>or equivalent. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The module assessment consists of a written exam 150 minutes. The lab course has to be passed. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the grade of the written exam. | |
| **Frequency** | annually, in the winter semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 09 08 | Room Acoustics/ Virtual Reality | Prof. Dr.-Ing. habil. E. Altinsoy |
| **Contents and objectives** | This module provides the theoretical and practical foundation for room acoustics (first part) and interface design for virtual reality applications (second part).<br>1)The first part of the module (room acoustics) includes the theory of sound fields in enclosed spaces, geometrical acoustics, sound absorbers, electroacoustic systems in rooms and design of lecture halls, concert halls, opera houses, etc.<br>2) The aim of the second part of the module is to present the advanced concepts for generation of real-time interactive auditory, haptic, and visual virtual environments. Nowadays, such kinds of systems play a pronounced role in scientific and industrial research & development and, thus, become more and more important as tools for automotive industry (e.g. driving simulators, prototyping of engineering designs, restyling, ergonomics, etc.), telecommunication industry, architecture, and entertainment industry. Students learn audio recording and reproduction technologies (binaural techn., stereophony, surround sound, VBAP, ambisonics, wave field synthesis), implementation of room acoustical models, sound synthesis techniques, haptic and visual reproduction technologies. Furthermore, students will be exposed to the process of creating virtual environments, by developing some small VR applications (auditory/haptic/visual) as members of a small team. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 2 hours per week practical lab courses, and self-study | |
| **Prerequisites** | Competences acquired in modules such as<br>Systems Theory,<br>Signal Theory,<br>Acoustics, or equivalent. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The module assessment consists an oral exam of 55 minutes as individual exam and a project work of 30 hours. | |
| **ECTS credit points and grades** | 7 ECTS credits points<br>The module grade is the arithmetic mean of the oral exam and the project work: M = (PL1 + PL2) / 2. | |
| **Frequency** | annually, in the summer semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 09 09 | Psychoacoustics / Sound Design | Prof. Dr.-Ing. habil. E. Altinsoy |
| **Contents and objectives** | This module gives an introduction to:<br>1.Psychoacoustics:<br>Psychoacoustics is concerned with the relationships between the physical characteristics of sounds and their perceptual attributes. The aim of this module is to give students an understanding on the theory and practice of psychophysics, including the various aspects of psycho-acoustics, such as sensitivity, masking, loudness, sharpness, pitch, timbre and roughness. In this module various binaural models and the aspects of the binaural hearing will be introduced.<br>2. Sound design<br>Each perceived sound in product use is a carrier of information. Each sound has a meaning to its listener, and as such each sound is perceived as a sign. The humming sound inside a car is mostly associated with, e.g., sportiness. This module outlines basic principles of sign theory and gives guidelines to how human perception of a product is affected by product sounds.<br>Intended learning outcomes:<br>Students learn to construct signals, which evoke – if they are heard – specific physical, affective or psychomotor reactions. They are qualified for the product development, e.g., in the automotive, hearing aid, household appliance or telecommunication industry and in medical engineering companies. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 2 hours per week tutorials, and self-study | |
| **Prerequisites** | Competences acquired in modules such as Measurement and Sensor Techniques, Acoustics, or equivalent. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The module assessment consists of a written exam of 90 minutes and a project of 30 working hours. | |
| **ECTS credit points and grades** | 7 ECTS credits<br>The module grade results from the arithmetic mean of both elements of assessment. | |
| **Frequency** | annually, in the winter semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 10 05 | Communication Networks, Advanced I | Prof. Dr.-Ing. Frank Fitzek |
| **Contents and objectives** | Content:<br>• The planning process for communication networks with transport, service and cost modelling and principles for the dimensioning and routing in communication networks, including their implementation in algorithmic or heuristic optimization approaches<br>• Integrated packet networks with selected basics of networking technologies and protocols for LAN, MAN and WAN<br>Objectives:<br>Having succeessfully completed this module, the students have a sound knowledge of planning, dimensioning and optimization of integrated communication networks. They understand the procedures and protocol structures that are used for efficient, flexible and reliable operation of these networks and have an overview of currently used technologies and their trends. The students are familiar with the basic technologies for integrated communication networks. They understand the system structures and processes and are able to evaluate and apply these. They master the most important networking technologies, their operating principles and protocols and are able to apply these to new problems. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 2 hours per week tutorials, and self-study | |
| **Prerequisites** | Competences acquired in modules such as<br>Communications Engineering and<br>Communication Networks, Basics,<br>or equivalent. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. If the number of registered students exceeds 15, the assessment consists of two written exams of 120 minutes each. With up to 15 registered students, the assessment consists of an oral exam as individual exam of 30 minutes and a written exam of 120 minutes. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the arithmetic mean of the grades for both elements of assessment. | |
| **Frequency** | annually, in the summer semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 10 19 | Optimization in modern Communication Systems | Prof. Dr.-Ing. Rafael F. Schaefer<br>rafael.schaefer@tu-dresden.de |
| **Contents and objectives** | Content:<br>The foundations of optimization in communication systems and modern methods of signal processing for communication in radio systems<br>Objectives:<br>The students are familiar with optimization problems that occur in communication technology as well as with modern approaches and methods of information theory and signal processing. The students have the mathematical knowledge necessary for classifying these problems and master both analytical methods as well as numerical<br>methods for the solution thereof. They are able to apply these to different scenarios and are thus able to develop optimal and efficient strategies for current problems in modern communication systems. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 2 hours per week tutorials, and self-study.<br>The language of instruction can be either German or English. At the beginning of the teaching period, the lecturer announces the language the module will be taught in. | |
| **Prerequisites** | Competences acquired in modules such as<br>Information Theory,<br>Systems Theory,<br>or equivalent. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The assessment consists of two written exams of 120 minutes each each. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the arithmetic mean of the grades for both elements of assessment. | |
| **Frequency** | annually, in the winter semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 10 20 | Communication Networks, Advanced II | Prof. Dr.-Ing. Frank Fitzek |
| **Contents and objectives** | Content:<br>• Tools for analyzing the performance of communication systems, in particular the analytical and simulative approach, and the exemplary realization by implementation<br>• Future communication systems, their planning, analysis and structure<br>• Approaches to project-based work, incl. work-structuring and presentation of the results (in writing and oral) in front of an expert public<br>Objectives:<br>Having successfully completed this module, the students have a thorough understanding of the modelling and performance analysis of communication networks and their protocols. They are able to chose and apply appropriate methods of investigation for various problems.<br>The students have learned to look at their tasks in a professional manner, to structure their project in terms of work and time, and to present their results in a public-oriented manner. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 2 hours per week tutorials, and self-study. The language of instruction is English. | |
| **Prerequisites** | Competences acquired in modules such as Communications Engineering, ET-12 10 04 Communication Networks, Basic Module, or equivalent. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. If the number of registered students exceeds 15, the assessment consists of a written exam o 120 minutes and a project of 30 hours. With up to 15 registered students, the assessment consists of an oral exam as individual exam of 30 minutes and a project work of 30 hours. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the arithmetic mean of the grades for both elements of assessment. | |
| **Frequency** | annually, in the winter semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 10 09 | Information Theory, Advanced I | Prof. Dr.-Ing. Rafael F. Schaefer<br>rafael.schaefer@tu-dresden.de |
| **Contents and objectives** | This module comprises:<br>Elements of the multi-user information theory, meaning capacity regions and attainable rate regions of multiple access channels, broadcast channels, relay channels, interference channels with coding theorems and converse<br>Intended learning outcome:<br>After completing this module, students are familiar with the elements of the network information theory and the basic results regarding capacity regions und attainable rate regions. Students further obtain information theoretical and mathematical tools to prove coding theorems. Amongst these coding theorems are superposition coding, Gelfand-Pinkser coding, dirty-paper coding, successive-interference-cancellation, Han-Kobayashi-coding, backward-decoding and many more. Furthermore, students will know the current status of technology – e.g. the capacity region of the multi-antenna broadcast channel – as well as unsolved issues regarding network information theory and its difficulties. They further apply their gained knowledge and the functional interpretation of system designs of future mobile communication systems, for cellular systems (multiple access and broadcast channel), relay and multi-hop systems as well as ad hoc networks to specific tasks. Moreover, they confidently deploy various performance metrics, are familiar with the stochastic description of wireless networks, and can evaluate average and outage-performances. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 2 hours per week tutorials, and self-study. The language of instruction can be German or English, and is announced at the beginning of the semester by the lecturer. | |
| **Prerequisites** | Competences provided by modules such as Information Theory. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The assessment consists of two written exams of 120 minutes each. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the arithmetic mean of the two written exams. | |
| **Frequency** | annually, in the winter semester | |

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|---|---|
| **Workload** | 210 hours |
| **Duration** | 1 semester |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 10 13 | RF Systems | Prof. Dr.-Ing. D. Plettemeier |
| **Contents and objectives** | The module content:<br>The operation and the physical basics of modern RF and wireless systems.<br>Objectives:<br>The students are familiar with ground- and satellite-based radio navigation and positioning systems. Communication satellite links can be described at system level. Basic understanding of satellite technology, antenna systems and phenomena of wave propagation (free space propagation, atmospheric absorption, plasma frequency, reflection and scattering, Doppler effect, etc.) are taught. The students are familiar with the different radar techniques (e.g. pulse-radar, pulse Doppler radar, FMCW radar and secondary radar, MTI principle, chirp) and with the system description and signal processing. They have obtained knowledge regarding the functionality and methods of the signal processing of radar imaging techniques (e.g. SAR principles). | |
| **Modes of teaching and learning** | 4 hours per week lectures, 2 hours per week tutorials, and self-study | |
| **Prerequisites** | Competences acquired in modules such as<br>RF Engineering, or equivalent. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The module assessment is an individual oral exam of 45 minutes. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the grade of the oral exam. | |
| **Frequency** | annually, in the summer semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 10 15 | Basics Mobile Communications Systems | Prof. Dr.-Ing. Dr. h.c. G. Fettweis |
| **Contents and objectives** | Having completed the module, the students know and understand the basic structure of cellular mobile communications systems (system and protocol architectures, radio network planning and optimization, capacity calculation). They are able to analyze und to solve problems of radio network planning. They know the phenomena of the mobile radio channel (Doppler effect, multipath propagation), master the basic principles of digital signal transmission over frequency-selective and time-variant transmission channels and are able to analyze, to describe mathematically and to work out solutions for real-word data transmission problems. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 2 hours per week tutorials, and self-study. | |
| **Prerequisites** | Competences acquired in modules such as Communications Engineering, Systems Theory, or equivalent. | |
| **Requirements for the award of credit points** | The credit points are earned if the module assessment is passed. If the number of registered students exceeds 15, the assessment consists of a written exam of 150 minutes. With up to 15 registered students, the writtem exam will be replaced by an oral exam of 45 minutes. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the grade of the exam. | |
| **Frequency** | annually, in the summer semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 10 16 | Digital Signal Processing and Hardware Implementation | Prof. Dr.-Ing. Dr. h.c. G. Fettweis |
| **Contents and objectives** | Having completed the module, the students master processes for software implementation of digital signal processing algorithms on different hardware platforms and can evaluate them with respect to various criteria.<br>The students know methods for hardware and software realization of communications engineering problems as well as design and optimization methods for digital signal processing systems. They are able to design and optimize signal processing systems in the field of communications by taking into account the mutual influence of the hardware and software (HW / SW co-design). | |
| **Modes of teaching and learning** | 2 hours per week lectures, 1 hours per week tutorial, 2 hours per week practical lab courses, and self-study.<br>The language of instruction is at least partially in English. | |
| **Prerequisites** | Competences acquired in modules such as<br>Introduction to Analysis and Algebra,<br>Calculus for Functions with Several Variables,<br>Complex Function Theory,<br>Communications Engineering,<br>Systems Theory. | |
| **Requirements for the award of credit points** | The credit points are earned if the module assessment is passed. The module assessment consists of two exams. Exam 1 is a written exam of 120 minutes if the number of participants exceeds 16. With up to 16 participants, the written exam will be replaced by an oral exam as an individual exam of 20 minutes. The type of exam will be announced at the end of the registration period at the faculty. Exam 2 is a lab report. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade results from the arithmetic mean of the grades of both elements of assessment. | |
| **Frequency** | annually, beginning in the summer semester | |
| **Workload** | 210 hours | |
| **Duration** | 2 semesters | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 10 16 | Digital Signal Processing and Hardware Implementation | Prof. Dr.-Ing. Dr. h.c. G. Fettweis |
| **Contents and objectives** | Having completed the module, the students master processes for software implementation of digital signal processing algorithms on different hardware platforms and can evaluate them with respect to various criteria.<br>The students know methods for hardware and software realization of communications engineering problems as well as design and optimization methods for digital signal processing systems. They are able to design and optimize signal processing systems in the field of communications by taking into account the mutual influence of the hardware and software (HW / SW co-design). | |
| **Modes of teaching and learning** | 2 hours per week lectures, 1 hours per week tutorial, 2 hours per week practical lab courses, and self-study.<br>The language of instruction is at least partially in English. | |
| **Prerequisites** | Competences acquired in modules such as<br>Introduction to Analysis and Algebra,<br>Calculus for Functions with Several Variables,<br>Complex Function Theory,<br>Communications Engineering,<br>Systems Theory. | |
| **Requirements for the award of credit points** | The credit points are earned if the module assessment is passed. The module assessment consists of two exams. Exam 1 is a written exam of 120 minutes if the number of participants exceeds 16. With up to 16 participants, the written exam will be replaced by an oral exam as an individual exam of 20 minutes. The type of exam will be announced at the end of the registration period at the faculty. Exam 2 is a lab report. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade results from the arithmetic mean of the grades of both elements of assessment. | |
| **Frequency** | Annually, in the summer semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 10 17 | Upgrade Mobile Communications Systems | Prof. Dr.-Ing. Dr. h.c. G. Fettweis |
| **Contents and objectives** | Contents of the module are special and/or current topics in the field of mobile communications.<br>The student has the option to choose two lectures from a catalogue of several lectures. Examples of contents to choose from:<br>1. Fundamentals of Estimation and Detection<br>2. Machine Learning in signal processing<br>3. Algorithms for multi-antenna systems<br><br>Objectives:<br>Having completed this module, the students are able to understand the concepts of modern mobile systems and to contribute creatively to solve radio transmission problems under mobile communications conditions. The students have a deeper understanding of the problems in mobile communications (signal transmission via disturbed frequency-variant and time-variant communication channels), have the knowledge and skills to analyze these problems theoretically, to develop and implement practical solutions.<br>The students are able to express themselves in English technical terminology. | |
| **Modes of teaching and learning** | The module includes lectures and tutorials in the amount of 6 hours per week, and self-study. The language of instruction is English. | |
| **Prerequisites** | Competences acquired in modules such as Communications Engineering, Systems Theory, or equivalent. | |
| **Requirements for the award of credit points** | The credit points are earned if the module assessment is passed. If the number of registered students exceeds 15, the module assessment is a written exam of 150 minutes. With up to 15 registered students, the written exam will be replaced by an oral exam as an individual exam of 45 minutes. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the grade of the exam. | |
| **Frequency** | Annually, in the winter semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 10 18 | Digital Signal Processing Systems | Prof. Dr.-Ing. Dr. h.c. G. Fettweis |
| **Contents and objectives** | Having completed the module, the students have the mathematical knowledge necessary for describing and analyzing discrete-time systems (e.g., fundamentals of time-discrete systems and spectral analysis of time, signal sampling and reconstruction, digital filtering, quantization, multirate systems, adaptive filtering), and can use this knowledge in the design and implementation of digital signal processing systems. The students are able to simulate signal processing modules and to implement them with the help of digital signal processors (DSPs). | |
| **Modes of teaching and learning** | 3 hours per week lectures, 1 hour per week tutorials, 2 hours per week practical lab courses, and self-study. | |
| **Prerequisites** | Competences acquired in modules such as<br>Introduction to Analysis and Algebra,<br>Calculus for Functions with Several Variables,<br>Complex Function Theory,<br>Systems Theory, or equivalent. | |
| **Requirements for the award of credit points** | The credit points are earned if the module assessment is passed. The module assessment consists of a written exam of 120 minutes and a lab report. | |
| **ECTS credit points and grades** | 7 ECTS credit point<br>The module grade results from the weighted grades of the elements of assessment; the written exam contributes by 2/3 and the lab report by 1/3. | |
| **Frequency** | Annually, in the winter semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

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

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 10 21 | Network Coding: Theory and Practice | Prof. Dr.-Ing. Frank Fitzek |
| **Contents and objectives** | Content:<br>• Theoretical fundamentals of network coding (NC)<br>• Evaluation of NC's performance in present and future communications systems<br>Objectives:<br>The students are able to cope with the joint treatment of coding and routing in networks. They know both the classic NC in wire-bound and the extension to the wireless case. They are familiar with current research topics in the fields of modulation and coding in networks as well as modern methods for data storage and secure data transmission, such as network coded modulation, lattice codes, compute-and-forward, distributed data storage and secure network coding. They know the performance of NC systems and are familiar with the simulation as well as the implementation of NC on simple communication systems. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 2 hours per week tutorials, and self-study<br>The language of instruction can either be German or English. At the beginning of the teaching period, the lecturer announces whether the module will be taught in English or German. | |
| **Prerequisites** | Competences acquired in modules such as<br>Information Theory,<br>Systems Theory,<br>Communication Networks, Basics<br>or equivalent. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. If the number of registered students exceeds 15, the assessment consists of two written exams of 120 minutes each. With up to 15 registered students, the written exams will be replaced by two oral exams as individual exams of 30 minutes each. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the arithmetic mean of the grades for both elements of assessment. | |
| **Frequency** | Annually, in the summer semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 10 22 | Intelligent and cooperative Communications | Prof. Dr.-Ing. Rafael F. Schaefer<br>rafael.schaefer@tu-dresden.de |
| **Contents and objectives** | The content of the module includes an introduction to basic concepts and algorithms of machine learning as well as modern methods of resource allocation in radio systems and their application to cooperative communication systems.<br><br>Objectives:<br>1. The students know and understand the basic structures, concepts and algorithms of machine learning and deep learning including application-related design, classification and training methods. They know typical and current problems and areas of application of machine learning and are able to evaluate them critically. They can design, train and validate problem-specific artificial neural networks with up-to-date software.<br>2. The students have an overview of cooperation techniques and their applications in modern communication networks. They know the approaches and methods of game theory and can use them to analyze conflict situations, such as those that occur when resources are allocated in communication systems. They are familiar with sample systems and the associated analytical and simulative considerations as well as exemplary implementation using implementation on practical systems. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 2 hours per week exercises, and self-study.<br><br>The language of instruction can be either German or English. At the beginning of the teaching period, the lecturer announces in which language the module will be taught. | |
| **Prerequisites** | Competences acquired in modules such as<br>Information Theory,<br>Systems Theory,<br>or equivalent. | |

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| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The module examination consists of a document PL1 for qualification objective 1 and a written exam PL2 of 120 minutes duration for qualification objective 2.<br>With up to 15 registered students, the examinations can be replaced by an oral examination as an individual examination of 30 minutes each. If applicable, this will be announced to the registered students at the end of the registration period, as is customary for the faculty. |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the arithmetic mean of the grades for both elements of assessment. |
| **Frequency** | Annually, in the summer semester |
| **Workload** | 210 hours |
| **Duration** | 1 semester |

| Module number | Module name | Lecturer in charge |
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| ET-12 08 27 | Neuromorphic VLSI Systems | Prof. Dr.-Ing. habil. Ch. G. Mayr |
| **Contents and objectives** | The content of the module includes:<br>- Design Methods for Integrated Analog CMOS circuits and their circuit sizing,<br>- neuromorphic VLSI systems and their neurobiological basics, common abstraction models, as well as the use in research and technology, eg. in brain-machine-interfaces and for signal processing,<br>- foundations, concepts and methods for the preparation and analysis of analog and neuromorphic CMOS circuits with the design software Cadence DF2.<br>Outcomes:<br>After completing the module, students will be familiar with the areaof neuronal networks from neurobiological foundations up to to the application circuit. They are able to work with design tools (Cadence DF2, Specter), to design and dimension CMOS circuits, and to verify the parameters by simulation and to create associated circuit layouts. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 2 hours per week tutorials, and self-study. | |
| **Prerequisites** | Competences acquired in modules such as<br>Basics of Electrical Engineering,<br>Circuit Design,<br>Systems Theory,<br>Numerical Analysis,<br>or equivalent. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment consists of an assignment and a report. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the grade is the weighted mean of the parts of the assessment: M = (2 PL1 + PL2 / 3.. | |
| **Frequency** | annually, in the summer semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

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| Module name | **Integrated Circuit Design for Biomedical Sensors** |
| Module number | EuI-IST-E-ICDBS<br>(EuI-NES-E-ICDBS) |
| Lecturer in charge | Prof. Dr.-Ing. Andreas Bahr<br>andreas.bahr@tu-dresden.de |
| Objectives | After completing the module, the students have an in-depth understanding of the design of analog integrated circuits as well as the design techniques and procedures. They know the major methods of design, simulation and layout of analog integrated circuits as well as the details and the use of a professional design frame work (Cadence). The students know how to simulate the electrical functionality of integrated circuits and how to consider further aspects like reliability aspects during the development phase.<br>They can apply this knowledge to biomedical sensor interface circuits and use this knowledge to create new analog integrated circuits and enhance existing ones. They can perform analysis of highly complex integrated analog circuits and apply strategies for the efficient technological realization of complex integrated circuits. |
| Contents | This course introduces the concepts and procedures of analog integrated circuit design – with a special focus on biomedical electronic sensor interface applications.<br>• Analog integrated circuits<br>• Amplifier circuits (low-noise, low-power design)<br>• Electronic Interface circuits for biomedical sensors<br>• Biomedical signal generation and information transfer<br>• Analog integrated circuit design-flow<br>• Circuit design techniques (e.g., gm/I_D methodology<br>• Simulation of analog integrated circuits, Spice<br>• Chip Engineering (floorplan, placement, routing, physical layout)<br>• Exemplified realizations of electronic interface circuits and electronically active implants |
| Modes of teaching and learning | 2 hours per week lectures, 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 programme Information Systems Engineering.<br>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 examination of 90 minutes and a portfolio of 80 hours. Both examinations have to be passed. |
| Credit points and grades | 7 credit points can be earned by the module. The module grade is the weighted mean of the grades of the assessments. The written exam is weighted by 3/4 and the portfolio is weighted by 1/4. |

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| 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 |
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| ET-12 11 04 | Sensors and Sensor Systems | Prof. Dr.-Ing. habil. G. Gerlach |
| **Contents and objectives** | The module comprises:<br>– Physical effects connecting diverse measurands of sensors with electronic sensor quantities<br>– Properties of sensors (material properties, transducer mechanisms, fabrication technology, construction of sensors, application requirements),<br>– Design, application and operation of sensors<br>Intended learning outcome:<br>After successfully passing the module students are able<br>– to apply physical basics of sensors,<br>– to connect coupling effects and interferences caused by material properties, fabrication and application,<br>– to estimate the impact of effects upon the sensor behaviour and to compare it with other influences, and<br>– to use sensors for diverse applications. | |
| **Modes of teaching and learning** | Lectures, tutorials, and lab work with at least 6 hours per week (typically 4 hours per week lectures, 1 hour per week tutorial, 1 hour per week practical lab course), and self-study. | |
| **Prerequisites** | Competences acquired in modules such as<br>Introduction to Analysis and Algebra,<br>Calculus for Functions with Several Variables,<br>Complex Function Theory,<br>Partial Differential Equations and Probability Theory,<br>Microsystems and Semiconductor Technology, or equivalent. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The module assessment consists of a written exam of 150 minutes and a lab course. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is calculated from the weighted mean of both the grade of the written exam (2/3) and the grade of the lab course (1/3). | |
| **Frequency** | annually, in the winter semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 11 05 | Plasma Technology | Prof. Dr. E. v. Hauff |
| **Objectives** | 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 contents include:<br>1. The fundamentals of plasma physics, industrial plasma processes, and process tool design<br>2. 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 hour per week tutorials, and self-study.<br>The language of instruction is English. | |
| **Prerequisites** | Competences acquired in modules such as Basics of Science. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The module assessment consists of a written exam of 90 minutes. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is the grade of the written exam. | |
| **Frequency** | annually, in the winter semester | |
| **Workload** | 210 hours | |
| **Duration** | 1 semester | |

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

| Module number | Module name | Lecturer in charge |
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| ET-12 12 04 | Memory Technology | Prof. Dr.-Ing. T. Mikolajick |
| **Contents and objectives** | This module covers memory concepts in the market and in research respectively development stage:<br>- Magnetic memories<br>- Optival memories<br>- Semiconductor memories (SRAM, DRAM, nonvolatile Memories (EPROM, EEPROM, Flash))<br>- Innovative semiconductor memories (e.g. ferroelectric, magnetoresistive, resisitive, organic, and single molecule memories)<br>Objectives:<br>After completion of the module the students have the competences to optimize and develop new generations of existing memory concepts. Based on the physical effects they will also be able to develop new memory concepts. Furthermore, the students are able to evaluate the areas of application for the memory concept and are aware of their limitation. | |
| **Modes of teaching and learning** | 3 hours per week lectures, 2 hours per week seminars, and self-study.<br>The module is taught in English. | |
| **Prerequisites** | Competencies acquired in modules such as<br>Microelectronic Technologies and Devices,<br>or equivalent. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. If the number of registered students exceeds 20, the module assessment consists of a written exam of 90 minutes. With up to 20 registered students, the written exam will be replaced by an oral exam as individual exam of 15 minutes. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The grade of the module is the grade of the exam. | |
| **Frequency** | Annually, beginning in the summer semester | |
| **Workload** | 210 working hours | |
| **Duration** | 2 semesters | |

| Module number | Module name | Lecturer in charge |
|---|---|---|
| ET-12 13 11 | Nonlinear Control Systems, Advanced | Prof. Dr.-Ing. habil. Klaus Röbenack |
| **Contents and objectives** | Content:<br>• Mathematical tools of nonlinear systems (e.g. differential geometry)<br>• System theoretical elements of complex control systems (e. g. spatially distributed systems)<br>Objectives:<br>The students are capable of analyzing complex control systems and dimension nonlinear control systems. They are able to model, identify, analyze, control and regulate complex control systems (e.g. spatially distributed systems) by means of mathematical and system theoretical correlations. | |
| **Modes of teaching and learning** | 4 hours per week lectures, 1 hour per week tutorial, and self-study | |
| **Prerequisites** | Competences acquired in modules such as Systems Theory and Control of Continuous-Time Processes. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The assessment consists of two written exams of 90 minutes each. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is determined by the arithmetic mean of both exams. | |
| **Frequency** | Annually<br>The module starts in the summer semester. | |
| **Workload** | 210 hours | |
| **Duration** | 2 semesters | |

| Module number | Module name | Lecturer in charge |
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| ET-12 13 12 | Optimal and Robust Multi-variable Control Systems | Prof. Dr.-Ing. habil. K. Röbenack |
| **Contents and objectives** | Content:<br>1. Analysis and design of optimal and / or robust control<br>2. Design of control concepts for multivariable systems or systems with model uncertainties<br><br>Objectives:<br>The students create optimal or robust controls and regulations (controller design). They are able to develop control concepts for multivariable systems or systems with model uncertainties, e.g. for the simultaneous influencing or decoupling of several sizes. | |
| **Methods of teaching and learning** | 4 hours per week lectures, 1 hour per week tutorial, and self-study | |
| **Prerequisites** | Competences in the field of Control of Continuous-Time Processes. | |
| **Requirements for the award of ECTS credit points** | The credit points are earned if the module assessment is passed. The assessment consists of two written exams of 90 minutes. | |
| **ECTS credit points and grades** | 7 ECTS credit points<br>The module grade is determined by the arithmetic mean of both exams. | |
| **Frequency** | Annually<br>The module starts in the summer semester. | |
| **Workload** | 210 hours | |
| **Duration** | 2 semesters | |

| Module number | Module name | Responsible lecturer |
|---|---|---|
| INF-BAS1 | Introduction to Applied Computer Science | Prof. Dr. Martin Wollschlaeger<br>martin.wollschlaeger@tu-dresden.de |
| **Contents and qualification objectives** | The students master the basic principles of engineering information technology in flexible automated systems according to the requirements of man and environment. The content of the module is chosen by the students: Methods for modeling and simulation, analysis and performance evaluation of complex dynamic systems, approaches to solve practical technical decision problems, specifics of networked systems or real-time systems, methods for planning and controlling complex technical systems, methods of design, specification and implementation of networked industrial application systems, methods for testing and trouble-shooting in software applications, techniques of task analysis and evaluation methods for the usable design of interactive systems. | |
| **Teaching and learning methods** | The module includes 4 SWS (semester weeks) lectures and 4 SWS exercises and the self-study. The language of the lectures and/or exercises can be German or English and will be determined at the beginning of the semester. | |
| **Prerequisites for participation** | Knowledge and skills in the basics of statistics, object-oriented programming, the basics of distributed systems, computer networks and software design are required. With the following literature, students can prepare for the module:<br>Christian Ullenboom, Java is also an island: Learning programming with the standard work for Java developers, Rheinwerk Computing; Edition: 12, 2016, ISBN: 978-3836241199.<br>Andrew s. Tanenbaum: Computer Networks. Prentice Hall, Pearson Education Germany.<br>Alan Dix, Janet Finlay, Gregory D. Abowd: Human Computer Interaction, Prentice Hall, Pearson. | |
| **Usability** | The module is one of eight compulsory elective basic modules of the Master's programme in Computer Science, of which three are to be selected, one of seven compulsory elective basic modules of the Diploma programme in Computer Science, of which three are to be selected and one of four compulsory elective basic modules of the Diploma programme in Information Systems Engineering, of which one is to be selected. In the aforementioned Diploma programme in Computer Science, it fulfils the prerequisites for the compulsory elective advanced modules *Advanced Applied Computer Science* (INF-VERT1), *Introduction to Basic Research in Computer Science* (INF-PM-FOR) and *Introduction to Applied Research in* | |

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| | *Computer Science* (INF-PM-ANW). |
| **Requirements for the awarding of credit points** | The credit points are awarded if the module examination is passed. If there are more than 40 registered students, the module examination consists of a written examination with a duration of 90 minutes. If there are 40 or fewer registered students, it consists of an oral examination with a duration of 30 minutes; this will be announced to the registered students as usual at the faculty at the end of the registration period. |
| **Credit points and grades** | The module allows for the earning of 12 credit points. The module grade corresponds to the grade of the examination. |
| **Frequency of the module** | The module is offered each semester. |
| **Workload** | The workload is a total of 360 hours. |
| **Duration of the module** | The module takes one semester. |

| Module number | Module name | Responsible lecturer |
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| INF-BAS2 | Artificial Intelligence | Dr. Bjoern Andres<br>bjoern.andres@tu-dresden.de |
| **Contents and qualification objectives** | The students understand the theory and master the methods for the independent conception, construction and programming of intelligent systems. Students are able to familiarize themselves with various topics in the field of artificial intelligence in both industry-related and research-oriented contexts and to apply their knowledge to solve problems independently. The content of the module is chosen by the students: Modelling and analysis of visual objects as well as methods of pattern recognition and computer vision, modeling and solution of complex problems with the help of declarative programming languages, ontology languages and other techniques of computational logic, theory of learning and advanced approaches in the field of machine learning and of statistical learning and methods for self-learning systems, techniques for solving planning and configuration problems as well as the combination of planning, decision theory and execution in rational agents and mobile robots, construction and methodology of autonomous robots, basic techniques for autonomous systems in complex systems that act rationally despite possible erroneous data and uncertain knowledge. | |
| **Teaching and learning methods** | The module includes lectures, exercises and seminars in the amount of 8 SWS (semester weeks) and the self-study. The courses are to be selected from the INF-BAS2 catalogue to the specified extent, including at least 2 SWS lectures and 2 SWS exercises. Some courses of this module can be offered in English. The catalogue will be announced as usual at the Faculty of Computer Science, at the beginning of each semester, including the language of the courses. | |
| **Prerequisites for participation** | Knowledge and skills in the basics of artificial intelligence (search methods, knowledge representation, machine learning) are required. With the following literature, students can prepare for the module:<br><br>Russell & P. Norvig: Artificial Intelligence - A Modern Approach. | |
| **Usability** | In the Master's programme in Computer Science, the module is one of eight elective basic modules, of which three must be chosen and one of seven elective basic modules, of which three must be chosen in the Diploma programme in Computer Science. | |

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| | This module fulfils the prerequisites for the following compulsory elective modules: *Advanced Artificial Intelligence* (INF-VERT2), *Introduction to Basic Research in Computer Science* (INF-PM-FOR) and *Introduction to Applied Research in Computer Science* (INF-PM-ANW) of the aforementioned Diploma programme. |
| **Requirements for the awarding of credit points** | The credit points are awarded if the module examination is passed. The module examination consists of an oral examination, with a duration of 30 minutes. At the student's request, the oral examination may be conducted in English. |
| **Credit points and grades** | The module allows for the earning of 12 credit points. The module grade corresponds to the grade of the oral examination. |
| **Frequency of the module** | The module is offered each semester. |
| **Workload** | The workload is a total of 360 hours. |
| **Duration of the module** | The module takes two semesters. |

| Module number | Module name | Responsible lecturer |
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| INF-BAS3 | Software and Web Engineering | Prof. Dr. Raimund Dachselt<br>raimund.dachselt@tu-dresden.de |
| **Contents and qualification objectives** | The students master the basic principles of the engineering of software, web and multimedia applications and the associated processes. You can design, implement and evaluate simple applications with graphical and web-based interfaces. The content of the module is chosen by the students: Software Technologies, Web & Multimedia Engineering and Usability Engineering. | |
| **Teaching and learning methods** | The module includes lectures, exercises and seminars in the amount of 8 SWS (semester weeks) and the self-study. The courses are to be selected from the INF-BAS3 catalogue of the Faculty of Computer Science to the specified extent, including at least 2 SWS lectures and 2 SWS exercises. Some courses of this module can be offered in English. The catalogue will be announced as usual at the faculty, at the beginning of each semester, including the language of the courses. | |
| **Prerequisites for participation** | Skills and abilities in the basics of programming (e.g. in Java and JavaScript), software technology (e.g. UML) and markup languages (e.g. XML) are required. The following literature will help students to prepare for the module:<br><br>Helmut Balzert, Textbook of Software Engineering, 2nd edition. Heidelberg, 2000, ISBN 3-8274-0042-2.<br><br>Christian Ullenboom, Java is also an island: Learning programming with the standard work for Java developers, Rheinwerk Computing; Edition: 12, 2016, ISBN: 978-3836241199.<br><br>Balzert, Helmut; Krüger, Sandra. HTML5, XHTML & CSS: Developing websites systematically & barrier-free - [ 2nd ed. Witten : W3L, 2011. ISBN: 9783937137544. http://katalogbeta.slub- dresden.de/id/0011609301/. | |
| **Usability** | The module is one of eight compulsory elective basic modules in the Master's programme in Computer Science, of which three are to be selected, one of seven compulsory elective basic modules in the Diploma programme in Computer Science, of which three are to be selected and one of four compulsory elective basic modules in the Diploma programme in Information Systems Engineering, of | |

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| | which one is to be selected. It fulfils the prerequisites for the compulsory elective compulsory modules *Advanced Software and Web Engineering* (INF-VERT3) in the Master's and Diploma programmes in Computer Science and the prerequisites for the compulsory elective profile modules *Introduction to Basic Research in Computer Science* (INF-PM-FOR) and *Introduction to Applied Research in Computer Science* (INF-PM-ANW) in the Diploma programme in Computer Science. |
| **Requirements for the awarding of credit points** | The credit points are awarded if the module examination is passed. The module examination consists of an oral examination with a duration of 30 minutes. At the student's request, the oral examination may be conducted in English. |
| **Credit points and grades** | The module allows for the earning of 12 credit points. The module grade corresponds to the grade of the oral examination grade. |
| **Frequency of the module** | The module is offered each semester. |
| **Workload** | The workload is a total of 360 hours. |
| **Duration of the module** | The module takes one semester. |

| Module number | Module name | Responsible lecturer |
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| INF-BAS4 | System Architecture | Prof. Dr. Wolfgang Lehner<br>wolfgang.lehner@tu-dresden.de |
| **Contents and qualification objectives** | The students have the technical and methodological competence to analyze, design, validate and operate system architectures not only under functional but also under non-functional aspects such as effort, costs, real time, fault tolerance, security and data protection. The content of the module is chosen by the students: Operating systems, databases, computer networks, fault tolerance, data protection and data security. | |
| **Teaching and learning methods** | The module includes lectures, exercises and seminars in the amount of 8 SWS (semester weeks) and the self-study. The courses are to be selected from the INF-BAS4 catalogue of the Faculty of Computer Science, to the specified extent, including at least 2 SWS lectures and 2 SWS exercises. Some courses of this module can be offered in English. The catalogue will be announced as usual at the faculty, at the beginning of each semester, including the language of the courses. | |
| **Prerequisites for participation** | Knowledge and skills in the basics of databases, computer networks, operating systems and security at Bachelor level are required. The following literature will help students to prepare for the module:<br>Andrew S. Tanenbaum: Modern operating systems.<br>Andrew S. Tanenbaum: Computer Networks.<br>David Kahn: The Codebreakers: The Comprehensive History of Secret Communication from Ancient Times to the Internet.<br>Theo Härder, Erhard Rahm: Database systems. Concepts and techniques of implementation. | |
| **Usability** | The module is one of eight compulsory elective basic modules in the Master's programme in Computer Science, of which three are to be selected, one of seven compulsory elective basic modules in the Diploma programme in Computer Science, of which three are to be selected and one of four compulsory elective basic modules in the Diploma programme in Information Systems Engineering, of which one is to be selected. In the aforementioned Diploma programme in Computer Science, it fulfils the prerequisites for the compulsory elective advanced and profile modules *Advanced* | |

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| | *System Architecture* (INF-VERT4), *Introduction to Basic Research in Computer Science* (INF-PM-FOR) and *Introduction to Applied Research in Computer Science* (INF-PM-ANW)). |
| **Requirements for the awarding of credit points** | The credit points are awarded if the module examination is passed. The module examination consists of an oral examination with a duration of 30 minutes. At the student's request, the oral examination may be conducted in English. |
| **Credit points and grades** | The module allows for the earning of 12 credit points. The module grade corresponds to the grade of the oral examination. |
| **Frequency of the module** | The module is offered each semester. |
| **Workload** | The workload is a total of 360 hours. |
| **Duration of the module** | The module takes two semesters. |

| Module number | Module name | Responsible lecturer |
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| INF-BAS5 | Computer Engineering | Prof. Dr. Wolfgang Nagel<br>wolfgang.nagel@tu-dresden.de |
| **Contents and qualification objectives** | Students know system architectures and modeling paradigms of VLSI systems, are able to verify descriptions of hardware systems by simulation and convert them into real circuits using typical tools. You know different implementation concepts for embedded systems and can describe them with formal means. They understand how the systems are embedded in their environment and how they are connected to it. You understand the interweaving of hardware and software in embedded systems and can derive design decisions from this. You know different approaches to formulate parallel programs. You understand how these formulations are mapped to different parallel computers and can estimate or evaluate the effects of program alternatives and architectural decisions. The contents of the module are design, modeling, programming, simulation and realization of technical systems in the fields of VLSI systems, embedded systems and parallel processing. | |
| **Teaching and learning methods** | The module includes lectures, exercises, practical courses and seminars in the amount of 8 SWS (semester weeks) and the self-study. The courses are to be selected from the INF-BAS5 catalogue of the Faculty of Computer Science, to the specified extent, including at least 2 SWS lectures, 2 SWS exercises and 2 SWS internships. Some courses of this module can be offered in English. The catalogue will be announced as usual at the faculty, at the beginning of each semester, including the language of the courses. | |
| **Prerequisites for participation** | Knowledge and skills in the basics of digital circuits, computer organization and computer architecture are required. The following literature will help students to prepare for the module:<br><br>Lipp & Becker: Basics of digital technology.<br><br>David Patterson (author), John LeRoy Hennessy: Computer organization and computer design: The hardware/software interface.<br><br>Hennessy & Patterson: Computer Architecture. A Quantitative approach. | |

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| **Usability** | The module is one of eight compulsory elective basic modules in the Master's programme in Computer Science, of which three are to be selected, one of seven compulsory elective basic modules in the Diploma programme in Computer Science, of which three are to be selected and one of four compulsory elective basic modules in the Diploma programme in Information Systems Engineering, of which one is to be selected. In the aforementioned Diploma programme in Computer Science, it fulfils the prerequisites for the compulsory elective advanced and profile modules *Advanced Computer Engineering* (INF-VERT5), *Introduction to Basic Research in Computer Science* (INF-PM-FOR) and *Introduction to Applied Research in Computer Science* (INF-PM-ANW). |
| **Requirements for the awarding of credit points** | The credit points are awarded if the module examination is passed. The module examination consists of an oral examination with a duration of 30 minutes. A collection of minutes must be prepared as a preliminary examination performance. |
| **Credit points and grades** | The module allows for the earning of 12 credit points. The module grade corresponds to the grade of the oral examination. |
| **Frequency of the module** | The module is offered in the winter semester. |
| **Workload** | The workload is a total of 360 hours. |
| **Duration of the module** | The module takes one semester. |

| Module number | Module name | Responsible lecturer |
|---|---|---|
| INF- VERT1 | Advanced Applied Computer Science | Prof. Dr. Martin Wollschlaeger martin.wollschlaeger@tu-dresden.de |
| **Contents and qualification objectives** | Students know advanced engineering methods for flexible automated systems over their entire life cycle. They can transfer engineering methods to novel application systems, apply them in an integrated way and develop components of such systems independently. The content of the module can be chosen by the students: Design and synchronization of multimodal user interfaces using visual, speech-based and haptic interaction techniques, assistive technologies, simulative performance evaluation of complex dynamic systems, industrial simulation projects including common statistical methods and modelling approaches, planning and control approaches from production and logistics, Resource scheduling problems, design of networked software systems including wireless networks and sensor-actuator networks and methods for modelling, specification, description, engineering and management of industrial communication systems, information models and systems for complex networked production systems. | |
| **Teaching and learning methods** | The module includes courses in the amount of 10 SWS (semester weeks) and the self-study. At least 4 SWS lectures and 2 SWS exercises are to be selected from the INF-VERT1 catalogue of the Faculty of Computer Science. 4 SWS lectures, exercises, seminars and internships listed in the catalogue can be freely selected. Some courses in this module may be offered in English. The catalogue will be announced as usual at the Faculty of Computer Science, at the beginning of each semester, including the language of the course. | |
| **Prerequisites for participation** | Competences to be acquired in the module INF-BAS1 Applied Computer Science, or equivalent. | |
| **Usability** | The module is one of seven compulsory elective advanced modules in the Master's programme in Computer Science, of which one is to be selected, and one of seven compulsory elective advanced modules in the Diploma programme in Computer Science, of which one is to be selected. It is also one of four compulsory elective advanced modules in the Diploma | |

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| | programme in Information Systems Engineering, of which one must be selected. |
| **Requirements for the awarding of credit points** | The credit points are awarded if the module examination is passed. The module examination consists of an oral examination performance, with a duration of 40 minutes. At the student's request, the oral examination may be conducted in English. |
| **Credit points and grades** | The module allows for the earning of 15 credit points. The module grade corresponds to the grade of the oral examination. |
| **Frequency of the module** | The module is offered each semester. |
| **Workload** | The workload is a total of 450 hours. |
| **Duration of the module** | The module takes two semesters. |

| Module number | Module name | Responsible lecturer |
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| INF- VERT2 | Advanced Artificial Intelligence | Dr. Bjoern Andres<br>bjoern.andres@tu-dresden.de |
| **Contents and qualification objectives** | The students are able to specify intelligent systems by means of formal methods, procedures and algorithms, they can prove properties of intelligent systems by means of formal methods, procedures and algorithms and they can introduce the used formal methods, procedures and algorithms into further applications. The contents of the module are as chosen by the students: Knowledge representation and inference, computational logic, pattern recognition and computer vision as well as bioinformatics. | |
| **Teaching and learning methods** | The module includes courses in the amount of in total 10 SWS (semester weeks) and the self-study. At least 4 SWS lectures and 2 SWS exercises are to be selected from the INF-VERT2 catalogue of the Faculty of Computer Science. 4 SWS lectures, exercises, seminars and internships listed in the catalogue are to be freely selected. Some courses in this module may be offered in English. The catalogue will be announced as usual at the Faculty of Computer Science, at the beginning of each semester, including the language of the courses. | |
| **Prerequisites for participation** | Competences acquired in the module INF-BAS2 Artificial Intelligence, or equivalent. Literature: Russel S. and Norvig, P.: Artificial Intelligence: A Modern Approach, Prentice Hall, 2009. | |
| **Usability** | In the Master's programme in Computer Science, the module is one of seven compulsory elective advanced modules of which one must be chosen, and one of seven compulsory elective advanced modules of which one must be chosen in the Diploma programme in Computer Science. | |
| **Requirements for the awarding of credit points** | The credit points are awarded if the module examination is passed. The module examination consists of an oral examination performance with a duration of 40 minutes. At the student's request, the oral examination may be conducted in English. | |
| **Credit points and grades** | The module allows for the earning of 15 credit points. The module grade corresponds to the grade of the oral examination. | |

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| **Frequency of the module** | The module is offered each semester. |
| **Workload** | The workload is a total of 450 hours. |
| **Duration of the module** | The module takes two semesters. |

| Module number | Module name | Responsible lecturer |
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| INF-VERT3 | Advanced Software and Web Engineering | Prof. Dr. Raimund Dachselt<br>raimund.dachselt@tu-dresden.de |
| **Contents and qualification objectives** | The students know advanced development methods and tools for the engineering of software, web, and Multimedia applications and the associated processes. With the help of modern frameworks, they can design and implement complex distributed applications with multimedia interfaces and evaluate their usability. The content of the module can be chosen by the students: Software technologies, web & multimedia engineering and usability engineering. | |
| **Teaching and learning methods** | The module includes courses in the amount of 10 SWS (semester weeks) and the self-study. At least 4 SWS lectures and 2 SWS exercises are to be chosen from the INF-VERT3 catalogue of the Faculty of Computer Science. 4 SWS lectures, exercises, seminars and internships listed in the catalogue can be freely chosen. Some courses of this module can be offered in English. The catalogue will be announced as usual at the faculty, at the beginning of each semester, including the language of the courses. | |
| **Prerequisites for participation** | Competences to be acquired in the module INF-BAS3 Software and Web Engineering, or equivalent. | |
| **Usability** | The module is one of seven compulsory elective advanced modules in the Master's programme in Computer Science, of which one is to be chosen, and one of seven comulsory elective advanced modules in the Diploma programme in Computer Science, of which one is to be chosen. It is also one of four compulsory elective advanced modules in the Diploma programme in Information Systems Engineering, of which one must be chosen. | |
| **Requirements for the awarding of credit points** | The credit points are awarded if the module examination is passed. The module examination consists of an oral examination performance with a duration of 40 minutes. At the student's request, the oral examination may be conducted in English. | |

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| **Credit points and grades** | The module allows for the earning of 15 credit points. The module grade corresponds to the grade of the oral examination. |
| **Frequency of the module** | The module is offered each semester. |
| **Workload** | The workload is a total of 450 hours. |
| **Duration of the module** | The module takes two semesters. |

| Module number | Module name | Responsible lecturer |
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| INF- VERT4 | Advanced System Architecture | Prof. Dr. Wolfgang Lehner<br>wolfgang.lehner@tu-dresden.de |
| **Contents and qualification objectives** | Students can independently develop new concepts and solutions for the analysis, design, validation and operation of complex system architectures. They consider both functional and non-functional aspects such as effort, costs, real time, fault tolerance, security and data protection. Furthermore, they are able to consider new research-oriented problems in this area under possible economic and social effects. The contents of the module can be chosen by the students: Operating systems, databases, computer networks, fault tolerance, data protection and data security. | |
| **Teaching and learning methods** | The module includes courses in the amount of 10 SWS (semester weeks) and the self-study. At least 4 SWS lectures and 2 SWS exercises are to be chosen from the INF-VERT4 catalogue of the Faculty of Computer Science. 4 SWS lectures, exercises, seminars and internships listed in the catalogue can be freely chosen. Some courses of this module can be offered in English. The catalogue will be announced as usual at the faculty, at the beginning of each semester, including the language of the courses. | |
| **Prerequisites for participation** | Competences to be acquired in the module INF-BAS4 System Architecture, in particular basic knowledge of databases (relational databases, Entity Relationship Model, XML data model), computer networks (transmission methods, network technologies, Internet protocol mechanisms), operating systems (memory and process management, quantitative methods, process communication) and security (multilateral security, protection targets, attack models, security mechanisms). | |
| **Usability** | The module is one of seven compulsory elective advanced modules in the Master's programme in Computer Science, of which one is to be chosen, and one of seven compulsory elective advanced modules in the Diploma programme in Computer Science, of which one is to be selected. It is also one of four compulsory elective advanced modules in the Diploma pro-gramme in Information Systems Engineering, of which one must be chosen. | |

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| **Requirements for the awarding of credit points** | The credit points are awarded if the module examination is passed. The module examination consists of an oral examination performance with a duration of 40 minutes. At the student's request, the oral examination may be conducted in English. |
| **Credit points and grades** | The module allows for the earning of 15 credit points. The module grade corresponds to the grade of the oral examination. |
| **Frequency of the module** | The module is offered each semester. |
| **Workload** | The workload is a total of 450 hours. |
| **Duration of the module** | The module takes two semesters. |

| Module number | Module name | Responsible lecturer |
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| INF- VERT5 | Advanced Computer Engineering | Prof. Dr. Wolfgang Nagel<br>wolfgang.nagel@tu-dresden.de |
| **Contents and qualification objectives** | The students are able to develop new approaches for design, realization, use and evaluation of computer architectures and hardware implementations of technical systems by recombination and extension of known concepts. The contents of the module are as chosen by the students: Performance evaluation of computer systems; hardware and software techniques for parallel processing, design and testing of VLSI circuits, programmable circuits, computer arithmetic, hardware and software architecture of embedded systems; methods for hardware synthesis and efficient methods for code generation. | |
| **Teaching and learning methods** | The module includes courses in the amount of 10 SWS (semester weeks) and the self-study. At least 4 SWS lectures and 2 SWS exercises are to be chosen from the INF-VERT5 catalogue of the Faculty of Computer Science. 4 SWS lectures, exercises, seminars and internships listed in the catalogue can be freely chosen. Some courses of this module can be offered in English. The catalogue will be announced as usual at the faculty, at the beginning of each semester, including the language of the courses. | |
| **Prerequisites for participation** | The competences to be acquired in the module INF-BAS5 Computer Engineering, or equivalent. | |
| **Usability** | The module is one of seven compulsory elective advanced modules in the Master's program in Computer Science, of which one is to be chosen, and one of seven compulsory elective advanced modules in the Diploma programme in Computer Science, of which one is to be chosen. It is also one of four compulsory elective advanced modules in the Diploma programme in Information Systems Engineering, of which one must be chosen. | |
| **Requirements for the awarding of credit points** | The credit points are awarded if the module examination is passed. The module examination consists of an oral examination performance with a duration of 40 minutes. | |

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| **Credit points and grades** | The module allows for the earning of 15 credit points. The module grade corresponds to the grade of the oral examination. |
| **Frequency of the module** | The module is offered each semester. |
| **Workload** | The workload is a total of 450 hours. |
| **Duration of the module** | The module takes two semesters. |

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| Module name | **Software Fault Tolerance Lab** |
| Module number | INF-IST-E-SFT.Lab |
| Lecturer in charge | Prof. Dr. Christof Fetzer<br>christof.fetzer@tu-dresden.de |
| Objectives | Students will be able able to minimize the error susceptibility of software systems. They can analyze existing systems, evaluate their error susceptibility, and reduce it by using various mechanisms. |
| Contents | The module covers the practical application of various fault-tolerant mechanisms and analysis methods that can be applied statically or dynamically. This includes, in particular, the development and optimization of fault-tolerant, reliable software. |
| Modes of teaching and learning | 4 hours per week practical lab courses and self-study.<br>The language of instruction is English. |
| Prerequisites | Skills in programming and RoboLab, operating systems, and software technology are required. |
| Requirements for the award of credit points | The credit points are awarded when the module assessment is passed. The module assessment consists of an ungraded complex assignment worth 90 minutes. The language of examination is English. |
| Credit points and grades | 6 credit points can be earned by the module. The module examination is graded as “pass” or “fail.” |
| Frequency | The module is offered every winter semester. |
| Workload | The total effort is 180 hours. |
| Duration | The module takes one semester. |

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| Module name | **Software Fault Tolerance** |
| Module number | INF-IST-E-SFT<br>(INF-NES-E-SFT) |
| Lecturer in charge | Prof. Dr. Christof Fetzer<br>christof.fetzer@tu-dresden.de |
| Objectives | Students are able to develop fault-tolerant software systems that minimize the probability of failure and increase security. Students are familiar with the various types and classes of faults and can analyze and evaluate their probability of failure. Students can apply various principles of robustness to minimize the probability of system failure. |
| Contents | The module covers the theoretical fundamentals of various fault-tolerant mechanisms and analysis methods that 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 security of such systems against attacks are also covered in the module. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. The language of instruction for lectures and exercises is English. |
| Prerequisites | Skills in programming and RoboLab, operating systems, computer networks, systems engineering and software technology are required. |
| 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. The language of examination is English. |
| Credit points and grades | 6 credit points can be earned by the module. The module grade is the grade of the examination. |
| Frequency | The module is offered every summer semester. |
| Workload | The total effort is 180 hours. |
| Duration | The module takes one semester. |

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| Module name | **Advanced Computer Networks** |
| Module number | INF-IST-E-RNA |
| Lecturer in charge | Prof. Dr. Matthias Wählisch<br>matthias.waehlisch@tu-dresden.de |
| Objectives | Students are familiar with practical aspects of computer networks and the technologies, concepts, and protocols necessary for their operation. They are able to analyze, plan, and design networks themselves and have advanced knowledge in the field of network and Internet security. |
| Contents | The module covers various computer network protocols across all layers of the TCP/IP protocol stack, the architecture of the internet, routing protocols, and the fundamentals of network management, security, virtualized networks, and networks for data centers or cloud infrastructures, current standards, their further development, and practical developments from research. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. The language of instruction for lectures and exercises may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Prerequisites | Skills in programming and RoboLab, computer networks, software technology, data management foundations, and automata and computability theory are required. |
| 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. The language of examination may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Module name | **Decentralized Systems** |
| Module number | INF-IST-E-Dec |
| Lecturer in charge | Prof. Dr. Florian Tschorsch<br>florian.tschorsch@tu-dresden.de |
| Objectives | Students are able to evaluate the functioning and use of decentralized approaches in various areas of application. |
| Contents | The module provides a comprehensive overview of decentralized systems and their scope for design. The focus is on the fundamental concepts, principles, and applications of decentralized systems, as well as the associated challenges and innovations. This includes protocols, algorithms, and incentive systems for the fault-tolerant and secure operation of distributed systems, in particular the design principles of blockchain technologies and, building on these, system properties such as decentralization, openness, and distributed trust. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. The language of instruction for lectures and exercises may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Prerequisites | Skills in algorithms and data structures, and computer networks are required. |
| 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 and an ungraded complex assignment worth 60 hours. The language of the two examinations may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 6 credit points can be earned by the module. The module grade is the unweighted mean of the examination; the following rule applies: graded examination results graded as “pass” are not included in the further calculation of grades; ungraded examination results graded as “fail“ are included in the further calculation of grades with a grade of “unsatisfactory” (5.0). |
| Frequency | The module is offered every winter semester. |
| Workload | The total effort is 180 hours. |
| Duration | The module takes one semester. |

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| Module name | **Distributed Systems** |
| Module number | INF-IST-E-DS<br>(INF-NES-E-DS) |
| Lecturer in charge | Dr. Thomas Springer<br>thomas.springer@tu-dresden.de |
| Objectives | After completing the module, students will be familiar with the requirements and basic principles relating to the design, structure, and requirements of distributed systems. They will be able to analyze and evaluate distributed applications. They will also have a fundamental understanding of how to break down large monolithic applications into their individual components in order to design scalable, distributed systems. |
| Contents | The module covers various architectures and communication mechanisms of distributed systems as well as the fundamentals of distributed transactions, security aspects, name and directory services, and current trends, standards, and research topics in the context of distributed systems. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. The language of instruction for lectures and exercises is English. |
| Prerequisites | Skills in programming and RoboLab, computer networks, software technology, and data management foundations are required. |
| 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. The language of the examination is English. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Module name | **Engineering Adaptive Mobile Applications** |
| Module number | INF-IST-E-EAMA |
| Lecturer in charge | Dr. Thomas Springer<br>thomas.springer@tu-dresden.de |
| Objectives | After completing the module, students will be familiar with the challenges of context-sensitive applications for mobile ubiquitous systems and adaptation mechanisms for such applications. In addition, they will be able to apply and transfer this knowledge independently by designing and implementing adaptive applications for mobile and ubiquitous systems, as well as evaluating and improving existing systems. |
| Contents | The module covers the fundamental challenges of mobile, ubiquitous applications, including, for example, the problems of context sensitivity and platform independence. The module also covers solution concepts and technologies for the development of applications for mobile and ubiquitous infrastructures. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. The language of instruction for lectures and exercises is English. |
| Prerequisites | Skills in computer networks, software technology, and data management foundations are required. |
| 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 assignment worth 90 hours. The language of the examination may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Module name | **Internet Measurements** |
| Module number | INF-IST-E-IM |
| Lecturer in charge | Prof. Dr. Matthias Wählisch<br>matthias.waehlisch@tu-dresden.de |
| Objectives | Students are familiar with practical methods for measuring and evaluating globally distributed communication infrastructures, services, and applications offered and used by different parties. They are familiar with the technologies, concepts, and protocols necessary for operation, can design measurements and experiments, and analyze networks. They are able to identify the associated challenges, have basic knowledge in the field of network and Internet security, and are able to efficiently evaluate large data sets. |
| Contents | The module covers the internal structure of the Internet and the proliferation of services and applications based on it. The focus is on measurement methods based on current research results in order to better understand the typical implementation of current communication standards and their further development in the global Internet. Furthermore, concrete examples of the proliferation of traditional and novel network protocols, such as BGP, IPv6, DNSSEC, and QUIC, including their quantification and limitations, are included. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. The language of instruction for lectures and exercises may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Prerequisites | Skills in programming and RoboLab, computer networks, safety, software technology, data management foundations, and automata and computability theory are required. |
| Requirements for the award of credit points | The credit points are awarded when the module assessment is passed. The module assessment consists of an ungraded complex assignment worth 45 hours and a written examination of 90 minutes. Bonus points for the written examination can be earned by completing practical lab course tasks comprising 15 hours. The examination language for the complex assignment and the written examination may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 6 credit points can be earned by the module. The module grade is the unweighted mean of the examination; the following rule applies: graded examination results graded as “pass” are not included in the further calculation of grades; ungraded examination results graded as “fail“ are included in the further calculation of grades with a grade of “unsatisfactory” (5.0). |
| Frequency | The module is offered every winter semester. |

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

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| Module name | **IoT Communication** |
| Module number | INF-IST-E-IoT<br>(INF-NES-E-IoT) |
| Lecturer in charge | Prof. Dr. Matthias Wählisch<br>matthias.waehlisch@tu-dresden.de |
| Objectives | Students have a qualified understanding of designing, implementing, and evaluating communication solutions for networks with low-resource end devices. Students can apply the basic theoretical concepts in practice and are able to set up and configure an IoT network in principle, as well as develop applications for it. |
| Contents | The module covers the fundamentals and innovative approaches to communication between low-resource devices and the Internet, as well as between devices themselves. This includes network architectures, protocols, services, and applications. The focus is on open solutions and standards that enable global communication between a wide variety of network participants. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. The language of instruction for lectures and exercises may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Prerequisites | Skills in programming and RoboLab, computer networks, software technology, and data management foundations are required. |
| Requirements for the award of credit points | The credit points are awarded when the module assessment is passed. The module assessment consists of an ungraded portfolio worth 30 hours and a written examination of 90 minutes. The examination language for the portfolio and the written examination may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 6 credit points can be earned by the module. The module grade is the unweighted mean of the examination; the following rule applies: graded examination results graded as “pass” are not included in the further calculation of grades; ungraded examination results graded as “fail“ are included in the further calculation of grades with a grade of “unsatisfactory” (5.0). |
| Frequency | The module is offered every winter semester. |
| Workload | The total effort is 180 hours. |
| Duration | The module takes one semester. |

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| Module name | **Microkernel-Based Operating Systems** |
| Module number | INF-IST-E-MOS |
| Lecturer in charge | Prof. Dr. Horst Schirmeier<br>horst.schirmeier@tu-dresden.de |
| Objectives | Students will be able to design and implement microkernel-based operating systems and assess and evaluate them in terms of functional and non-functional properties. |
| Contents | The module covers various aspects and concepts involved in the design and implementation of microkernel-based operating systems. It includes both fundamental design principles and real systems, in particular the microkernel work being done at TU Dresden. Other topics include the analysis of research papers in the field of microkernels and the implementation of components of a microkernel-based operating system and application software based on it. |
| Modes of teaching and learning | 2 hours per week lectures, 4 hours per week exercises and self-study. The language of instruction for lectures and exercises is English. |
| Prerequisites | Skills in operating systems, computer networks, computer architecture and hardware lab, software technology, and data management foundations are required. |
| 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. The examination language may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 9 credit points can be earned 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 270 hours. |
| Duration | The module takes one semester. |

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| Module name | **Prediction and Estimation Techniques** |
| Module number | INF-IST-E- PrET |
| Lecturer in charge | Dr. Waltenegus Dargie<br>waltenegus.dargie@tu-dresden.de |
| Objectives | Students are familiar with probabilistic prediction and estimation techniques. They are able to apply and evaluate these techniques in the context of distributed dynamic adaptive systems. |
| Contents | The module covers the fundamentals of probabilistic forecasting and estimation techniques, including the introduction and combination of random variables, the minimization of uncertainty, and the concept of minimum mean square estimation. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. The language of instruction for lectures and exercises is English. |
| Prerequisites | Skills in computer networks, software technology, data management foundations, and automata and computability theory are required. |
| 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. The examination language is English. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Module name | **Scalable Data Engineering** |
| Module number | INF-IST-E- SDE |
| Lecturer in charge | Prof. Dr.-Ing. Wolfgang Lehner<br>wolfgang.lehner@tu-dresden.de |
| Objectives | Students are familiar with advanced concepts for analyzing large data sets in the field of data science. They are also familiar with the entire process from data collection to evaluation using appropriate concepts and tools. They have knowledge of the individual steps involved in data extraction, inspection (data profiling), data quality assessment (data scrubbing), the modeling required for analytical environments (data warehousing, data lakes), and finally the classes of analysis methods for achieving the qualification goals. Students are able to assess the complexity of data analysis and select appropriate methodological and technical solutions, evaluating their advantages and disadvantages. They are familiar with the practical use of individual tools for the various process steps. |
| Contents | The module covers the entire data analysis process, from the collection of extensive data sets to the discussion of individual analysis methods, such as data profiling, schema discovery, data quality assessment, and modeling alternatives for analytical access patterns. Other topics include systematic analysis algorithms from different classes of methods with regard to satisfying the user's information needs and the technical implications for the system. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. The language of instruction for lectures and exercises may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Prerequisites | Skills in data management foundations are required. |
| 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 25 minutes. The examination language may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Accompanying literature | http://www.sde.db-tu-dresden.de |

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| Module name | **Scalable Data Management** |
| Module number | INF-IST-E- SDM |
| Lecturer in charge | Prof. Dr. Dirk Habich<br>dirk.habich@tu-dresden.de |
| Objectives | Students are familiar with advanced concepts of scalable database technology. They have knowledge of concepts for linking multiple computer nodes to form a large database management system and thus of implementation techniques for distributed data management, particularly with regard to scale-out architectures. They are familiar with various concepts, from tight coupling via shared disk to shared-nothing, to the synchronization of independent database systems via data propagation and data replication. Students are able to evaluate different scale-in techniques in terms of the resulting effort and benefits with regard to various usage requirements. They understand the characteristics of the different architectural approaches and can select them according to the requirements of the specific application. |
| Contents | The module covers concepts and methods of scalable database systems as a fundamental technology for the analytical and transactional processing of typically large data sets. This includes the two key aspects of performance and consistency, which are considered in relation to each other. With regard to performance, the focus is on issues of scalability in the case of scale-out architectures. Further content on the aspect of consistency includes different methods for synchronizing concurrent read and write activities on replicated data sets. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. The language of instruction for lectures and exercises is English. |
| Prerequisites | Skills in data management foundations are required. |
| 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 25 minutes. The examination language may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Accompanying literature | http://www.sdm.db-tu-dresden.de |

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| Module name | **Service and Cloud Computing** |
| Module number | INF-IST-E- SCC |
| Lecturer in charge | Dr. Iris Braun<br>iris.braun@tu-dresden.de |
| Objectives | Students are familiar with the fundamentals and challenges of service-oriented applications in distributed systems. They are able to apply this knowledge independently and transfer it to unknown problems by designing and implementing service-oriented applications or architectures for distributed systems and analyzing, evaluating, and optimizing existing systems. |
| Contents | The module covers the fundamentals and challenges of service-oriented applications and architectures for distributed systems, including service distribution, composition of distributed service-oriented applications, load balancing, redundancy, and selected security aspects. The module covers solution concepts and technologies for the development of service-oriented architectures and applications for distributed systems, particularly in the context of cloud computing. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. |
| Prerequisites | Skills in programming and RoboLab, computer networks, software technology, operating systems, and data management foundations are required. |
| 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 assignment of 90 hours. The examination language may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Module name | **Systems Engineering** |
| Module number | INF-IST-E-SE<br>(INF-NES-E-SE) |
| Lecturer in charge | Prof. Dr. Christof Fetzer<br>christof.fetzer@tu-dresden.de |
| Objectives | Students are able to design distributed software platforms using modern hardware and software components. They understand the challenges that distributed systems pose in terms of programming and correct execution, can evaluate these challenges, and apply appropriate mechanisms. They are able to design highly scalable and distributed systems that can be operated in cloud environments and are familiar with approaches, principles, and concrete implementations for the correct operation of distributed applications. |
| Contents | The module covers the design, construction, and operation of software platforms as well as current topics in distributed systems architecture. 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. Further content includes specific examples of some services with large distributed systems that enable cloud computing, as well as the architecture, construction, and operation of scalable systems. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. The language of instruction for lectures and exercises is English. |
| Prerequisites | Skills in operatig systems, computer architecture and hardware lab, programming and RoboLab, and computer networks are required. |
| 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. The examination language is English. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Module name | **Cyber Physical Systems Modeling Lab** |
| Module number | INF-IST-E-CPSM.Lab1 |
| Lecturer in charge | Prof. Dr. Christoph Sommer<br>christoph.sommer@tu-dresden.de |
| Objectives | Students are able to work on simple research-related questions in the field of cyber-physical systems in a structured and scientific manner under supervision. |
| Contents | The module focuses on the practical development of results from simple, interrelated, research-oriented projects in the field of cyber-physical systems and their preparation. |
| Modes of teaching and learning | 4 hours per week practical lab courses and self-study.<br>The language of instruction may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Prerequisites | Skills in programming and RoboLab, computer networks, software technology, data management foundations, and automata and computability theory are required. |
| 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 assignment worth 80 hours. The examination language may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 6 credit points can be earned by the module. The module grade is the grade of the examination. |
| Frequency | The module is offered every semester. |
| Workload | The total effort is 180 hours. |
| Duration | The module takes one semester. |

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| Module name | **Engineering and Management of Industrial Networks** |
| Module number | INF-IST-E-EMIN |
| Lecturer in charge | Prof. Dr. Martin Wollschlaeger<br>martin.wollschlaeger@tu-dresden.de |
| Objectives | Students are familiar with the basic functions, processes, architectures, and operating principles for designing, monitoring, and influencing industrial communication systems. They can describe and classify the functions. They are able to model the relevant elements of the systems and components appropriately. Students can transfer the functions and processes to novel application systems and apply them in an integrated manner. |
| Contents | The module covers networked systems in industrial real-time applications, methods for their design and management, requirements of the area of application, and comparisons with existing solutions from both the IT domain and automation. Other topics include description tools and methods, as well as developments and trends for innovative systems. |
| Modes of teaching and learning | 3 hours per week lectures, 1 hour per week exercises and self-study.<br>The language of instruction for lectures and exercises may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Prerequisites | Skills in computer networks, software technology, data management foundations, and automata and computability theory are required. |
| 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. The examination language may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Module name | **Foundations of Cyber Physical Systems** |
| Module number | INF-IST-E-CPS |
| Lecturer in charge | Prof. Dr. Christoph Sommer<br>christoph.sommer@tu-dresden.de |
| Objectives | Students will learn the fundamentals of designing specifications, implementing, and simulating the performance evaluation of networked cyber-physical systems. They will be able to model, design, and implement simple cyber-physical systems, as well as design, conduct, and evaluate studies on their use. |
| Contents | The module covers cyber-physical systems and methods for their specification, implementation, and simulative performance evaluation, as well as requirements and solutions for applications of cyber-physical systems in various domains. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. The language of instruction for lectures and exercises may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Prerequisites | Skills in programming and RoboLab, computer networks, software technology, data management foundations, and automata and computability theory are required. |
| 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. The examination language may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Module name | **Industrial Internet of Things** |
| Module number | INF-IST-E-IIoT |
| Lecturer in charge | Prof. Dr. Martin Wollschlaeger<br>martin.wollschlaeger@tu-dresden.de |
| Objectives | Students are familiar with the basic architectures, technologies, and operating principles of the Internet of Things for applications in industrial automation. They are able to derive typical requirements for the use of such systems in complex networked production systems, select suitable technologies, and design application-specific solutions. Students can transfer the characteristics of the Industrial Internet of Things to novel application systems, apply them in an integrated manner, and independently develop components for such systems. |
| Contents | The module covers architectural concepts and technologies of the Internet of Things with a focus on industrial applications. This includes requirements from the application domain and the evaluation of technologies and solutions for networking and application. Other topics include the design of suitable software components for industrial use as well as developments and trends for novel systems. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week practical lab courses and self-study.<br>The language of instruction for lectures and practical lab courses may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Prerequisites | Skills in software technology, data management foundations, and automata and computability theory are required. |
| 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. The examination language may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Module name | **Cyber Physical Systems Modeling Lab Advanced** |
| Module number | INF-IST-E-CPSM.Lab2 |
| Lecturer in charge | Prof. Dr. Christoph Sommer<br>christoph.sommer@tu-dresden.de |
| Objectives | Students are able to work on research-related questions in the field of cyber-physical systems in a structured and scientific manner under supervision. |
| Contents | The module focuses on the practical development of results from advanced, interrelated, research-oriented projects in the field of cyber-physical systems and their preparation. |
| Modes of teaching and learning | 4 hours per week practical lab courses and self-study.<br>The language of instruction may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Prerequisites | Skills that can be accuired in the module Cyber Physical Systems Modeling Lab are required. |
| 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 assignment of 80 hours. The examination language may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 6 credit points can be earned by the module. The module grade is the grade of the examination. |
| Frequency | The module is offered every semester. |
| Workload | The total effort is 180 hours. |
| Duration | The module takes one semester. |

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| Module name | **Computer and Robot Assisted Surgery** |
| Module number | INF-IST-E-CRC |
| Lecturer in charge | Prof. Dr. Stefanie Speidel<br>stefanie.speidel@nct-dresden.de |
| Objectives | Students master the methodological and practical basics of computer- and robot-assisted surgery. They are able to apply the methods and work on new, interdisciplinary tasks, select suitable solution methods, and develop new solution methods. |
| Contents | The module covers computer and robot assisted surgery. It includes the fundamentals of image acquisition, medical image processing and segmentation, registration, the basics of robot and navigation systems, intraoperative support, and extended reality, as well as insights into current research, clinical issues, and application examp-les. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. The language of instruction for lectures and exercises is English. |
| Prerequisites | Skills that can be accuired in the module Introduction to Analysis and Algebra are required. |
| 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. The examination language is English. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Module name | **Computer Vision** |
| Module number | INF-IST-E-CV |
| Lecturer in charge | Prof. Dr. Stefanie Speidel<br>stefanie.speidel@nct-dresden.de |
| Objectives | Students master the methodological and practical basics of computer- and robot-assisted surgery. They are able to apply the methods and work on new, interdisciplinary tasks, select suitable solution methods, and develop new solution methods. |
| Contents | The module covers computer and robot assisted surgery. It includes the fundamentals of image acquisition, medical image processing and segmentation, registration, the basics of robot and navigation systems, intraoperative support, and extended reality, as well as insights into current research, clinical issues, and application examp-les. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. The language of instruction for lectures and exercises is English. |
| Prerequisites | Skills that can be accuired in the module Introduction to Analysis and Algebra are required. |
| 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. The examination language is English. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Module name | **Foundations of Data Visualisation** |
| Module number | INF-IST-E-FDV |
| Lecturer in charge | Prof. Dr. Stefan Gumhold<br>stefan.gumhold@tu-dresden.de |
| Objectives | Students master the fundamentals and practices of scientific visualization of measurement and experimental data as well as simulation results. They are familiar with the fundamentals of visual perception and its influence on the design of visualizations. Students can confidently specify data according to dimension, feature types, and structure and select appropriate visual attributes for a given specification. They are familiar with the most important forms of visualization for two-,<br>three-, and multidimensional observation spaces, as well as for scalar, vector, tensor-valued, and multidimensional feature values. They are able to select appropriate techniques for the respective visualization task. Students are familiar with basic presentation and interaction techniques and can implement them in an interactive visual analysis system. They are familiar with the most important visualization frameworks, have practical experience, and are able to select visualization frameworks appropriate to the task. |
| Contents | The module covers the fundamentals of data visualization, with regard to the representation of different types of data using visual attributes and insights into human visual perception. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. The language of instruction for lectures and exercises is English. |
| Prerequisites | Skills in programming and RoboLab, algorithms and data structures, Introduction to Analysis and Algebra are required. |
| 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. The examination language may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Module name | **Foundations of Virtual Reality** |
| Module number | INF-IST-E-FVR |
| Lecturer in charge | Jun. Prof. Dr. Matthew McGinity<br>matthew.mcginity@tu-dresden.de |
| Objectives | Students are familiar with the fundamentals of virtual reality and immersive media technologies. This includes knowledge of the perceptual and psychological foundations of immersive media and a basic understanding of the technical challenges involved in developing immersive systems and experiences. |
| Contents | The module covers definitions and the history of immersive media and related concepts, fundamentals of visual, acoustic, haptic, and multisensory perception, head tracking and head-mounted displays, 3D tracking, spatial audio and haptic interfaces, embodiment, social presence, software architectures, and world models for immersive simulations. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. The language of instruction for lectures and exercises is English. |
| Prerequisites | Skills in software technology are required. |
| 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. The examination language is English. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Module name | **Machine Learning** |
| Module number | INF-IST-E-ML |
| Lecturer in charge | Prof. Dr. Bjoern Andres<br>bjoern.andres@tu-dresden.de |
| Objectives | Students are familiar with the problems of supervised, semi-supervised, unsupervised, and structural machine learning as formulated as mathematical optimization problems. They understand the complexity of these problems and are able to prove this complexity themselves using theoretical computer science methods. They are familiar with efficient local search algorithms for learning decision trees, for logistic regression, for correlation clustering, for linear ordering, and for inference and learning in graphical models with factor graphs, and are able to implement and apply these algorithms themselves. They are familiar with the structure of simple artificial neural networks and the forward and backward propagation algorithms, and are able to implement and apply these algorithms yourself. You can present specialist results in English. |
| Contents | The module covers supervised machine learning as an optimization problem, regularized risk minimization, decision tree learning, logistic regression, neural networks, and the fundamentals of supervised deep learning, forward propagation and backward propagation algorithms, semi-supervised and unsupervised machine learning as an optimization problem, classification with more than two classes, correlation clustering, linear ordering, structural machine learning as an optimization problem, graphical models, factor graphs, Gibbs distribution, and message passing algorithms. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises, 4 days á 5 hours projects and self-study.<br>The language of instruction for lectures, exercises and projects is English. |

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| Prerequisites | Skills in algorithms and data structures, Introduction to Analysis and Algebra as well as Partial Differential Equations and Probability Theory are required.<br>The following literature is suitable for preparation:<br>Algorithms and Data Structures, Kurt Mehlhorn, Peter Sanders. Springer Berlin Heidelberg, 2008. ISBN: 978-3-540-77977-3. DOI: 10.1007/978-3-540-77978-0<br>Analysis 1, Konrad Königsberger. Springer Berlin Heidelberg, 2004. ISBN: 978-3-540-40371-5. DOI: 10.1007/978-3-642-18490-1<br>Analysis 2, Konrad Königsberger. Springer Berlin Heidelberg, 2013. ISBN: 978-3-662-05699-8. DOI: 10.1007/978-3-662-05699-8<br>Lineare Algebra, Gerd Fischer. Springer Spektrum Wiesbaden, 2014. ISBN: 978-3-658-03945-5. DOI 10.1007/978-3-658-03945-5<br>Einführung in die Wahrscheinlichkeitstheorie und Statistik, Ulrich Krengel. Vieweg+Teubner Wiesbaden, 2013. ISBN: 978-3-322-93581-6. DOI: 10.1007/978-3-322-93581-6<br>Theoretische Informatik, Lutz Priese, Katrin Erk. Springer Vieweg Berlin<br>Heidelberg, 2018. ISBN: 978-3-662-57408-9. DOI: 10.1007/978-3-662-57409-6 |
| 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. The examination language is English. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Module name | **Efficient Parallel Algorithms** |
| Module number | INF-IST-E-EPA |
| Lecturer in charge | Prof. Dr. Wolfgang Nagel<br>wolfgang.nagel@tu-dresden.de |
| Objectives | Students are familiar with common algorithms, can describe them, and implement them efficiently. They are able to evaluate algorithms according to their asymptotic time complexity and justify their statements. |
| Contents | The module covers concepts of parallel programming for the parallelization of algorithms and data structures. Other topics include search algorithms, sorting algorithms, graph algorithms, algorithms from linear algebra and their efficient implementation, parallelization, and the design principles and evaluation criteria for parallel algorithms. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study. |
| Prerequisites | Skills in programming and RoboLab as well as algorithms and data structures are required. |
| 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. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Module name | **Hardware Modeling and Simulation** |
| Module number | INF-IST-E-HMS<br>(INF-NES-E-HMS) |
| Lecturer in charge | Prof. Dr.-Ing. Diana Göhringer<br>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.<br>The language of instruction for lectures and exercises is English. |
| Prerequisites | Skills in programming and RoboLab are required. |
| Usability | The module is a required elective module in the Master's program Nanoelectronic Systems.<br>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. The examination language is English. |
| 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. |

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| Module name | **High Performance Computing** |
| Module number | INF-IST-E-HPC |
| Lecturer in charge | Prof. Dr. Wolfgang Nagel<br>wolfgang.nagel@tu-dresden.de |
| Objectives | Students can describe strategies and methods of parallel processing in parallel computer architectures and evaluate parallel architectures and network concepts and their suitability for various parallel algorithms. They are able to develop simple parallel programs that utilize different types of parallelism. |
| Contents | The module covers the fundamentals of high-performance computers and their programming, strategies and methods of parallel processing, including programming models widely used in supercomputing. Other topics include architecture and network concepts and the necessary algorithmic building blocks, closely linked to practical experience from the interdisciplinary field of work of the CIDS Department Center for Information Services and High Performance Computing (ZIH). |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study.<br>The language of instruction for lectures and exercises may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Prerequisites | Skills in operating systems as well as computer architecture and hardware lab are required.<br>The following literature is suitable for preparation:<br>Introduction to high performance computing for scientists and engineers, G. Hager, G. Wellein. CRC Press, 2010.<br>Computer Architecture, Fifth Edition: A Quantitative Approach, John L. Hennessy, David A. Patterson. Morgan Kaufmann Publishers Inc., 2011.<br>Programming: principles and practice using C++, Bjarne Stroustrup. Pearson International, 2014.<br>The Linux Command Line, 2nd Ed., W.E. Shotts. No Starch Press, 2019. |
| 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. The examination language is English. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Duration | The module takes one semester. |

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| Module name | **Highly Parallel Programming of GPUs** |
| Module number | INF-IST-E-HPGPU |
| Lecturer in charge | Prof. Dr. Wolfgang Nagel<br>wolfgang.nagel@tu-dresden.de |
| Objectives | Students are able to analyze and evaluate manycore architectures using graphics processing units (GPUs) as an example. They are able to develop and optimize algorithms for these architectures. |
| Contents | The module covers highly parallel algorithms for manycore architectures with a focus on modern graphics cards, which are used in both the consumer sector and high-performance computing. Other topics include programming models and programming techniques for massively parallel environments, various GPU APIs for parallelization, computer graphics, and deep learning, and working with remote GPU instances. |
| Modes of teaching and learning | 2 hours per week lectures, 1 hour per week exercises, 1 hour per week practical lab courses and self-study.<br>The language of instruction for lectures, exercises and practical lab courses may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Prerequisites | Skills in computer architecture and hardware lab are required.<br>The following literature is suitable for preparation:<br>Computer architecture: a quantitative approach, J. L. Hennessy, D. A. Patterson, Elsevier, 2011. Chapter 4<br>Programming: principles and practice using C++, Bjarne Stroustrup. Addison-Wesley, 2014. |
| 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. Bonus points for the written examination can be earned by 8 hours of programming. The examination language may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Module name | **Introduction to Computer Engineering** |
| Module number | INF-IST-E-ETI |
| Lecturer in charge | Prof. Dr. Wolfgang Nagel<br>wolfgang.nagel@tu-dresden.de |
| Objectives | Students can explain and evaluate implementation concepts for both embedded systems and parallel computers. They understand the interdependence of hardware and software in computer systems, can derive design decisions for embedded systems from this understanding, and implement these decisions using high-level synthesis tools. They can classify and evaluate reliability and low-power challenges in the design of embedded systems and describe and discuss modern design techniques such as approximate computing and new transistor technologies. They are able to use various approaches to formulate parallel programs and can assess how these are mapped to different architectures. You can assess and evaluate the effects of program alternatives and architecture decisions. In addition to manual parallelization, students can explain the challenges of automatic code parallelization, apply formal parallel computation models, and reproduce the basics of domain-specific languages. |
| Contents | The module covers the design, modeling, programming, simulation, and implementation of technical systems in the field of embedded systems and parallel processing. |
| Modes of teaching and learning | 4 hours per week lectures, 2 hours per week exercises, 2 hours per week practical lab courses and self-study.<br>The language of instruction for lectures, exercises and practical lab courses may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Prerequisites | Skills in computer architecture and hardware lab are required. |
| 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. The examination language may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 12 credit points can be earned 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 360 hours. |
| Duration | The module takes one semester. |

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| Module name | **Performance Analysis of Computing Systems** |
| Module number | INF-IST-E-PACS |
| Lecturer in charge | Prof. Dr. Wolfgang Nagel<br>wolfgang.nagel@tu-dresden.de |
| Objectives | Students are familiar with performance evaluation terminology and can use it confidently in technical discussions. They are able to develop and evaluate performance experiments. They can use queueing or simulation models confidently. |
| Contents | The module covers fundamental techniques from the fields of statistics, probability theory, experimental design, simulation, and queueing theory based on practical problems. |
| Modes of teaching and learning | 2 hours per week lectures, 2 hours per week exercises and self-study.<br>The language of instruction for lectures and exercises is English. |
| Prerequisites | Skills in programming and RoboLab as well as operating systems are required.<br>The following literature is suitable for preparation:<br>TU Dresden, ZIH HPC Compendium.<br>Systems Benchmarking: For Scientists and Engineers, S. Kounev, K. Lange, J. Kistowski, Springer, 2020. (ISBN: 3-030-41704-8)<br>Measuring Computer Performance. A Practitioner's Guide, David J. Lilja.<br>Cambridge University Press, 2000. (ISBN: 0-521-64105-5)<br>The Art of Computer Systems Performance Analysis, Raj Jain. Wiley, 1991 (ISBN: 0-471-50336-3)<br>Programming: principles and practice using C++, Bjarne Stroustrup. Addison-Wesley, 2014.<br>The Linux Command Line, 2nd Ed., W.E. Shotts. No Starch Press, 2019. |
| 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. The examination language may be German or English. This will be determined by the lecturer at the beginning of each semester and announced in the usual manner. |
| Credit points and grades | 6 credit points can be earned 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. |

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| Module name | **Adaptive Dynamic Systems Lab** |
| Module number | INF-IST-E-ADS.Lab |
| Lecturer in charge | Prof. Dr. Diana Göhringer<br>diana.goehringer@tu-dresden.de |
| Objectives | Students have practical experience in the field of reconfigurable computing systems and their applications, such as image processing and machine learning. They are able to independently and thoroughly familiarize themselves with a given task in the field of reconfigurable computing systems and work on it in a practical manner using scientific methods. |
| Contents | The module covers the design, simulation, evaluation, and verification of reconfigurable computing systems and their implementation using FPGA platforms or simulators. |
| Modes of teaching and learning | 4 hours per week practical lab courses and self-study.<br>The language of instruction is English. |
| Prerequisites | Skills in programming and RoboLab are required. |
| Requirements for the award of credit points | The credit points are awarded when the module assessment is passed. The module assessment consists of an ungraded complex assignment worth 90 minutes. The language of examination is English. |
| Credit points and grades | 6 credit points can be earned by the module. The module grade is the grade of the examination. |
| Frequency | The module is offered each semester. |
| Workload | The total effort is 180 hours. |
| Duration | The module takes one semester. |