unibz
Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

ELECTRONIC AND INFORMATION ENGINEERING
CORSO DI LAUREA IN INGEGNERIA ELETTRONICA E DELL'INFORMAZIONE
BACHELOR IN ELEKTRO- UND INFORMATIONSTECHNIK

Contenuto degli insegnamenti
Inhalt der Lehrveranstaltungen

Coorti dal 2025/2026
Kohorten ab 2025/2026

Primo anno / Erstes Jahr

Mathematical Analysis I (I year, I semester, 9 CFU)

- Introduction to real and complex numbers.
- Basic notions on real functions of one real variable.
- Real sequences and numerical series.
- Limits and continuity of functions.
- Infinite and infinitesimal functions: Landau symbols and rate of convergence.
- Differential calculus and its applications.
- Local comparison and Taylor expansions.
- Antiderivatives and integral calculus for functions of one real variable.
- Definite and improper Riemann integrals.

Mathematical Analysis II (I year, II semester, 9 CFU)

- Real functions of several real variables, partial derivatives and differentiability.
- Taylor's theorem for several variable functions, free and constrained maxima and minima.
- Curves and vector fields, gradient, divergence, rotor; conservativity of vector fields.
- Curvilinear integrals of scalar functions.
- Curvilinear integrals of vector fields.
- Double integrals.
- Triple integrals.
- Mention of surface integrals, and Gauss, Green, and Stokes theorems
- Elements of ordinary differential equations.

Linear Algebra (I year, I semester, 6 CFU)

- Vector spaces.
- Geometry of space.
- Matrices and their operations.
- Linear systems.
- Determinant and rank.
- Linear transformations.

Fundamentals of Programming (I year, I semester, 11 CFU)

1. **Module 1: Fundamentals of Programming (I year, I semester, 6 CFU)**

- Introduction to hardware and software, with computer organisation; data hierarchy; machine languages, assembly languages, high-level programming languages.
- Introduction to different programming paradigms, focusing on the structured programming paradigm.
- Introduction to Python: interactive mode, script mode, Jupyter. Structured programming: basic data types, variables, constants, operators and expressions; standard input/output handling;

control flow structures; file and error handling.
- Basic data structures/types of Python: (1) lists, (2) dictionaries, (3) tuples, (4) sets.
- Subroutines and functions in Python (with/without parameters; with/without return); functions and basic recursion in Python, e.g., some combinatorics.
- Basics of computational thinking to solve a computational problem and program a resolution in Python and Python-based languages, via physical-computing boards.

2. **Module 2: Fundamentals of Programming II (I year, II semester, 5 CFU)**
   - Introduction to C programming and toolchain.
   - C language: syntax and data types.
   - C memory management and activation record.
   - C programming techniques.
   - Debugging and software testing (debugging tools; writing safe and secure programs; type checking).

Physics I (I year, II semester, 7 CFU)
- Measurement and vectors: units of measurement, dimensions of physical quantities, mathematical operations with vectors.
- Kinematics: average and instantaneous velocity and acceleration, uniformly accelerated motion.
- Dynamics I: Newton's three axioms, work, energy, conservation of energy.
- Dynamics II: linear momentum, collisions, centre of mass.
- Rotation: angular displacement, mean and instantaneous angular velocity and acceleration, torque, moment of inertia, angular momentum.
- Thermal phenomena: thermal expansion, kinetic theory of gases, heat, ideal gases.
- Thermodynamics: Zeroth, first and second law, notable thermodynamic cycles, entropy.

Ubiquitous Sensing and Computing (I year, II semester, 9 CFU)
Module 1: Ubiquitous Computing (I year, II semester, 6 CFU)
- Principles about Sensing & Perception.
- Methodology & Prototyping (Rapid Prototyping with ProtoPie).
- Arduino Output (with a strong focus on programming, digital, analog, PWM, ADC) and Arduino Input: Switches, Debouncing, Playing with sensors.
- AdvancedIO: FSR, stretch sensors, sensitivity, offset, accuracy, dynamic range, linearity and noise, filtering the signals (moving mean filter, EMA, WEMA etc.). Arduino Motors: ERM/LRA, Interrupts, Memory Handling.
- Serial Communication (Sensors to Microcontroller, Microcontrollers to Computer, etc.), i2C, Series Peripheral Interface (SPI). Prototyping with Unity. OSC communication.
- Combining Unity & Arduino using OSC. Technology Trends.

Module 2: Ubiquitous Sensing (I year, II semester, 3 CFU)
- Introduction to sensors and measurement principles: understanding what sensors are, how they work, and their role in converting physical phenomena (e.g., temperature, light, force) into electrical signals.
- Types of sensors and their applications: exploring different sensor types (e.g., temperature, humidity, light, and magnetic field sensors), their working principles, and common real-world uses.
- Practical implementation of sensor systems.

Economics and Management (I year, I semester, 6 CFU)
- The company: objectives and context (basic concepts; classifications of companies; value chain; vision and mission; Porter's generic strategies; strategy tools).
- Essentials of financial accounting (accounting principles; balance sheet and income statement; financial statement preparation; ratio analysis).
- Investment analysis (actualization and capitalization; discounted payback period; net present value; internal rate of return).
- Other economic evaluation analyses (classification of costs; break-even point; make or buy choices).

Specialized Language (I year, II semester, 3 CFU)
Specialized Italian (I year, II semester, 3 CFU)
- Present Subjunctive forms and uses.
- Subjunctive Pasts: forms and uses

- Language for specific purposes vocabulary and syntax
- Discursive markers.

Specialized English (I year, II semester, 3 CFU)

- Writing academic emails: formal language/making polite requests/format & language of formal emails.
- Writing academic reports: formal language/discourse markers/structure & organization.
- Making academic presentations on a discipline-specific topic.
- Discipline-specific vocabulary: word formation & collocations.
- Paragraph writing: topic sentences, discourse markers & other organisational features.

Specialized German (I year, II semester, 3 CFU)

- Technical language: terminology, morphology, syntax, text structure.
- Informal and formal e-mails within the academic sector.
- Application and cover letter.
- Graphics on specific technical topics.
- Reports/ presentations on discipline-specific topics.

Secondo anno / Zweites Jahr

Physics 2 (II year, I semester, 7 CFU)

- Electrostatics I: electric charge; coulomb law; electric field; electric potential.
- Electrostatics II: Electric energy storage: capacitance; dielectrics
- Electric currents: Ohm's law; resistance; Joule's effect; power; direct/alternating current; electric circuits; Kirchhoff's laws.
- Magnetostatics: magnetostatic fields; magnetic induction; Lorentz's forces; Ampère's law; magnetic dipoles; magnetic energy.
- Electromagnetic induction and Faraday's law.
- Electromagnetic waves: Maxwell's equations; light propagation; polarization of electromagnetic waves.
- Optics: reflection, refraction, interference, diffraction. Thin lenses.

Basics of Electronics (II year, I semester, 9 CFU)

- Fundamentals of electrical engineering: electrical quantities, concept of bipoles and quadripoles; ideal and real generators; Kirchhoff's laws.
- Resistive circuits and adynamic bipoles: resistive bipoles and Ohm's law; Thevenin's and Norton's equivalent circuits; nodal analysis and circuit simplification; superposition principle.
- Dynamic circuits and transient response: introduction to dynamic bipoles; first and second order circuits; transient response and time-domain analysis.
- Sinusoidal circuit analysis: superposition in AC circuits; multi-frequency circuits and signal decomposition; Thevenin's and Norton's models in AC; nodal analysis in sinusoidal regimes.
- Power in sinusoidal mode: instantaneous and average power calculations; root mean square (RMS) values, complex power and power factor considerations.
- Biports and circuit interconnections: biports and their characteristics; connection methods and practical applications; analysis of biport circuits in both dynamic and sinusoidal regimes.
- Operational amplifiers: principles and working of op-amps; circuit configurations and feedback mechanism; analysis of op-amp circuits in dynamic and sinusoidal conditions.
- Frequency response and filters: transfer function and system behaviour; Decibel scale and Bode diagrams; design and analysis of filters.
- Circuit simulation with SPICE: introduction to SPICE as a simulation tool; modelling and analysis of electrical components; practical applications in circuit design.

Data Structures and Algorithm (II year, I semester, 6 CFU)

- Searching and sorting.
- Analysis of algorithms: correctness and complexity.
- Divide and conquer, recurrences
- Pointers, dynamic data structures, linked lists
- Elementary graph and tree algorithms.
- Abstract data types: stacks, queues, priority queues, maps.

Operating Systems and Networking (II year, II semester, 6 CFU)

- Operating Systems Structures
- Processes, Threads and Concurrency
- CPU Scheduling and Synchronization
- Memory and Mass-Storage
- I/O, File Systems
- Networks and Distributed Systems

Electronic Materials and Devices (II year, 14 CFU)

1. **Module 1: Introduction to Quantum Electronics (II year, I semester, 5 CFU)**
   - Failure of classical mechanics: Black Body Radiation, Photoelectric and Compton effects.
   - Early quantum theory: Wave nature of matter, Bohr atom, De Broglie hypothesis, early models of the atom.
   - Quantum Mechanics: wavefunction, Heisenberg Uncertainty Principle, 1D Schroedinger equation (particle in a box and tunnelling). Quantization of the angular momentum.
   - Quantum mechanics of the atom. Pauli Exclusion Principle.
   - Bloch Theorem. Model of Kronig and Penney.
2. **Module 2: Electronic Devices (II year, II semester, 9 CFU)**
   - Semiconducting materials.
   - Electronic properties of solids.
   - Semiconductor fabrication and characterization techniques.
   - PN junctions and diodes.
   - Transistors (Bipolar, FET)
   - Memories (DRAM; SRAM; Flash; resistive).
   - Photonic devices (LEDs; lasers; photodiodes; solar cells).
   - Other electronic devices.
   - Practical exercises and laboratory work.

Fundamentals of Systems and Control (II year, 12 CFU)

1. **Module 1: Systems & Control (II year, II semester, 6 CFU)**
   - Dynamic system modelling in frequency domain.
   - Dynamic system response.
   - Stability of linear control systems.
   - Root-locus analysis and design methods.
   - Frequency-response analysis and design methods.
   - Digital control systems (time permitting)
2. **Module 2: Systems & Control Lab (II year, II semester, 6 CFU)**
   - Introduction to Matlab.
   - Introduction to Simulink.
   - Matlab's toolboxes for control.
   - Simulation of dynamical systems in the frequency domain with the Control System Toolbox.
   - Computer-aided analysis and design in Matlab/Simulink.
   - Real experiments of control in the lab.

Probably Theory and Statistics (II year, I semester, 6 CFU)

- Basic concepts: probability spaces, conditional probability, Bayes' Theorem, independent events.
- Random variables: distribution, density, expectation, variance, covariance, law of large numbers.
- Special distributions: Bernoulli, Binomial, Poisson, Exponential, Normal, Chi-Square, t-Distribution.
- Sampling: sums of random variables, central limit theorem, sample variance.
- Parameter Estimation: maximum likelihood estimates, interval estimates, confidence intervals.
- Hypothesis testing: significance levels, test statistics, p-values.

Terzo anno / Drittes Jahr

Modern Control (III year, II semester, 9 CFU)

- Modelling and system analysis in state space (dynamic system modelling in time domain and state-space representation).
- Dynamic system response derived from state-space representation and steady-state error.
- Stability in state space.
- Control design in state space (Pole placement design techniques; controllability, observability, full-state observers).
- Optimal control of dynamic systems (Problems with fixed and variable endpoints as well as with equality and inequality constraints; maximum principle and Hamilton-Jacobi-Bellmann equation; linear quadratic regulator).
- Understanding of observers in control systems.
- Understanding of optimal state observers and Kalman filters.
- Computer-aided analysis and design using Matlab/Simulink.
- Implementation of controllers and experimental evaluation on real-hardware setups

Electronic Circuits and Systems (III year, 12 CFU)

1 Module 1: Analog Electronics (III year, I semester, 6 CFU)

- Diodes: diode models and circuits, rectifier circuits, diode-based voltage regulators, limiting and clamping circuits.
- Op Amps: advanced configuration of amplifiers, instrumentation amplifier, integrator and differentiator, op-amp non-idealities. The effect of positive feedback: oscillator circuits.
- MOSFET and BJT models: physical structure, I-V model, C-V model, parasitic capacitances and resistances, small-signal models, p-channel MOSFET, pnp BJT.
- Transistor amplifiers: basic principles, basic configurations, biasing networks, discrete-circuit and IC amplifiers. Differential amplifiers and the differential pair.
- Frequency response: low- and high-frequency responses, approximate analysis methodologies, high-frequency response of MOSFET amplifiers.
- Introduction to digital logic circuits: CMOS logic circuit topologies, dynamic operation, and power dissipation.

2 Module 2: Digital Circuits and Systems (III year, II semester, 6 CFU)

- Combinational logic and sequential logic, mealy and Moore finite state machine, programmable logic electronics (taxonomy; PAL, PLC; FPGA: introduction, interconnection resources, I/O reconfigurable blocks, programming; design flow; principles of design, Verilog, system Verilog and VHDL).
- Power supply generation and distribution: switching mode power supplies and linear regulators, heat management, battery management.
- Analog meets digital: analog to digital conversion, digital to analog conversion. Interference between analog and digital.
- Microcontroller units: architecture, peripherals, bus signal distribution; crosstalk, glitch, debounce. Clock generation and distribution. signals and bus signal distribution, clock generation and distribution.
- System on chip, system in package, system on module concept and applications. Input and output devices and interfaces (i2C, SPI, USB3, ETH).
- Laboratory experience programming embedded electronics on MCUs.

Robot Control (III year, I semester, 6 CFU)

- Robot kinematics and dynamics.
- Trajectory planning.
- Motion control.
- Interaction control.
- Vision-based control.
- Remote control.
- Computer-aided simulation and design.

Computer Architecture (III year, I semester, 6 CFU)

- Binary arithmetic (two's complement, IEEE 754 floating point format, issues with floating-point computations)
- General computer architecture (Von Neumann architecture; CPUs; bus; memory; peripherals)
- Instruction set architecture (CISC vs RISC architecture; instructions: data-movement, control-flow, arithmetic/logic; common ISAs: introduction to x86, ARM, RISC-V; assembly programming).
- CPU architecture (control unit, registers, ALU; fetch-decode-execute cycle; pipelining; super-scalar architecture; branch prediction; out-of-order execution; caches).
- Memory and buses (static vs dynamic memory; serial/parallel buses; synchronous/asynchronous buses; bus arbitration strategies; example of buses: PCI, PCI-Express, USB).
- Other topics (multi-processor and multi-core architectures; introduction to GPUs).

Machine Learning (III year, I semester, 6 CFU)

- Data analysis.
- Model selection.
- Supervised learning.
- Unsupervised learning.
- Reinforcement learning.
- Elements of deep learning.