Syllabus

Course Description

Course Title	Electronic Materials and Devices
Course Code	42436
Course Title Additional	
Scientific-Disciplinary Sector	NN
Language	English
Degree Course	Bachelor in Electronic and Information Engineering
Other Degree Courses (Loaned)	
Lecturers	Prof. Dr. Niko Stephan Münzenrieder, Niko.Muenzenrieder@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/42095 Prof. Franco Cacialli, Franco.Cacialli@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/47601
Teaching Assistant	
Semester	All semesters
Course Year/s	2
CP	14
Teaching Hours	84
Lab Hours	56
Individual Study Hours	210
Planned Office Hours	42
Contents Summary	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.
Course Topics	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) The topics covered include: • Physics of semiconductor materials (e.g., crystal structure, energy bands, density of states, dopants, electronic transport) • Nanotechnology • pn junctions and diodes • MOSFETs • JFETs • Bipolar junction transistors • Sensors • Other electronic devices • Practical exercises and laboratory work.
Keywords	Semiconductors Electronic properties of matter

	Electronic devices
Recommended Prerequisites	
Propaedeutic Courses	
Teaching Format	Frontal lectures, exercises, and laboratories.
Mandatory Attendance	suggested
Specific Educational Objectives and Learning Outcomes	to be inserted by the two lecturers
Specific Educational Objectives and Learning Outcomes (additional info.)	
Assessment	M1: Summative assessment Form: Written and oral (at the discretion of the examiner(s), based on the results of the written component). See also below. Details: Closed book exam The exam includes a written and an oral component. The written exam (1.5 hours) consists of two parts: a first part (problem 1) with a series of (mostly) qualitative or semi-quantitative questions based on the understanding of the topics covered in the lectures, as well as a second part (problems 2-3) consisting of several numerical or symbolic problems to be solved related to the various topics covered in the lectures. Oral component: The oral component is mandatory, but depending on the quality of the written exam, and the explanations given in the solution, the commission (at their discretion) may decide it is not necessary. The oral exam may include questions on the programme covered in the lectures (including those of the written part of the exam) and may lead to an increase or a reduction of the grade of the written component. Importantly, if a student is requested by the commission to attend and sit the oral exam, and the student fails to do so, the exam will be considered as "not presented". Grading for all components will be based upon: - The correctness of the approach and the mathematical steps of the solution, the calculation of numerical results and the correct use of physical quantities and units. - The correctness of the provided answers and of the explanation

	presented, as well as the terminology used. To pass the exam the final grade must be greater or equal to 18. If the final score is greater than 30, a "cum laude" grade is awarded. The student can have access to the exam with pen, pencil and a portable calculator. A short list of constants is provided to the students along with the text of the exam. Students should also be able provide proof of identity (e.g. Campus card, ID card, passport) before the start of the exam. M2: The exam will be in in written form. Students will have the choice to take an oral midterm exam to earn a bonus of up to 5 points out of 30 for the final mark. The students might also have the possibility to substitute a part of the final exam with a group project to be carried out during the semester and concluded by an oral presentation.
Evaluation Criteria	M1: The exam includes a practical, a written and an oral component. The written exam (1.5 hours) consists of two parts: a first part (problem 1) with a series of (mostly) qualitative or semi-quantitative questions based on the understanding of the topics covered in the lectures, as well as a second part (problems 2-3) consisting of numerical or symbolic problems to be solved related to the various topics covered in the lectures. Oral component: The oral component is mandatory, but depending on the quality of the written exam, and the explanations given in the solution, the commission (at their discretion) may decide it is not necessary. The oral exam may include questions on the programme covered in the lectures (including those of the written part of the exam) and may lead to an increase or a reduction of the grade of the written component. Importantly, if a student is requested by the commission to attend and sit the oral exam, and the student fails to do so, the exam will be considered as "not presented". Grading for all components will be based upon: - The correctness of the approach and the mathematical steps of the solution, the calculation of numerical results and the correct use of physical quantities and units. - The correctness of the provided answers and of the explanation presented, as well as the terminology used.

	To pass the exam the final grade must be greater or equal to 18. If the final score is greater than 30, a "cum laude" grade is awarded. The student can have access to the exam with pen, pencil and a portable calculator. A short list of constants is provided to the students along with the text of the exam. Students should also be able provide proof of identity (e.g. Campus card, ID card, passport) before the start of the exam. M2: The assessment criteria will be the accuracy of the answers given in the written examination, with particular attention to the resolution procedure adopted and the formal correctness of the same.
Required Readings	Various textbooks can be used as a reference for the electronic devices module, for example: · „Semiconductor Physics and Devices", Donald A. Neamen · „Physics of Semiconductor Devices", S. M. Sze and Kwok K. Ng · „Microelectronics", Jacob Millman and Arvin Grabel · „The Art of Electronics", Paul Horowitz and Winfield Hill
Supplementary Readings	
Further Information	
Sustainable Development Goals (SDGs)	Quality education

Course Module

Course Constituent Title	M1 Introduction to Quantum Electronics
Course Code	42436A
Scientific-Disciplinary Sector	FIS/03
Language	English
Lecturers	Prof. Franco Cacialli, Franco.Cacialli@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/47601
Teaching Assistant	
Semester	First semester

CP	5
Responsible Lecturer	
Teaching Hours	30
Lab Hours	20
Individual Study Hours	75
Planned Office Hours	15
Contents Summary	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.
Course Topics	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. The hydrogen atom. Schroedinger equation and the 4 quantum numbers. Pauli Exclusion Principle. • Quantum mechanics of molecules, formation of chemical bonds, covalent and ionic bonds. • Quantum mechanics of solids: metallic bonds, statistical methods, density of states, Fermi level, electron gas at 0K and higher temperatures. • Model of Kronig and Penney. Energy bands, Brillouin zones and reduced representation of energy bands.
Teaching Format	Lectures with in class exercises and demonstrations.

Required Readings	Blackboard / lecture slides *Physics for Scientists and Engineers with Modern Physics*, Douglas C. Giancoli, Pearson, 4th edition, 2008. Also available in electronic format (pdf) from UNIBZ library. · *Physics for Scientists and Engineers*, Paul A. Tippler, Macmillan, 6th edition, 2007 Subject Librarian: David Gebhardi, David.Gebhardi@unibz.it and Ilaria Miceli, Ilaria.Miceli@unibz.it
Supplementary Readings	· C. Kittel, *Introduction to Solid State Physics*, 8th ed., John Wiley & Sons, 2005. · N. W. Ashcroft and N. D. Mermin, *Solid State Physics*, Holt, Rinehart and Winston, 1976.

Course Module

Course Constituent Title	M2 Electronic Devices
Course Code	42436B
Scientific-Disciplinary Sector	IINF-01/A
Language	English
Lecturers	Prof. Dr. Niko Stephan Münzenrieder, Niko.Muenzenrieder@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/42095
Teaching Assistant	
Semester	Second semester
CP	9
Responsible Lecturer	
Teaching Hours	54
Lab Hours	36
Individual Study Hours	135
Planned Office Hours	27
Contents Summary	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.
Course Topics	2. Module 2: Electronic Devices (II year, II semester, 9 CFU) The topics covered include: • Physics of semiconductor materials (e.g., crystal structure, energy bands, density of states, dopants, electronic transport) • Nanotechnology • pn junctions and diodes • MOSFETs • JFETs • Bipolar junction transistors • Sensors • Other electronic devices • Practical exercises and laboratory work.
Teaching Format	Lectures with in class exercises and demonstrations. Practical sessions.
Required Readings	Various textbooks can be used as a reference, for example: • „Semiconductor Physics and Devices", Donald A. Neamen • „Physics of Semiconductor Devices", S. M. Sze and Kwok K. Ng • „Microelectronics", Jacob Millman and Arvin Grabel • „The Art of Electronics", Paul Horowitz and Winfield Hill
Supplementary Readings	