Stampare su carta intestata del CdS

General information		
Academic subject	***Solid State Physics***	
Degree course	*LM-17 Physics*	
Academic Year	*2021-2022*	
European Credit Transfer and Accumulation System (ECTS)		6
Language	*English*	
Academic calendar (starting and ending date)	*1st year, 2nd Semester*	
Attendance	*No*	

Professor/ Lecturer	
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Virtual headquarters	
Tutoring (time and day)	Monday 03:00-05:00 pm Wednesday 03:00-05:00 pm

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Syllabus	
Learning Objectives	• Knowledge and understanding of crystal structure as well as of electronic, thermal and vibrational properties of solid-state crystals. • Capability to apply quantum mechanics for theoretical and numerical calculations in solid state physics and low dimensional systems. • Discuss theoretical models described during the course and apply them for solving problems reported in literature. • Follow current progress and future perspectives in the field of solid-state physics.
Course prerequisites	Background knowledge on quantum mechanics, statistical physic and semiconductor physics.
Contents	**Crystal Structure.** Periodic Array of Atoms. Lattice Translation Vectors. Primitive Lattice Cell. Fundamental Types of Lattices. Two-Dimensional Lattice Types. Three-Dimensional Lattice Types. Index Systems for Crystal Planes and Directions. Simple Crystal Structures. Sodium Chloride Structures. Cesium Chloride Structures. Diamond Structure. Zinc Blende Structure. Problems. **Reciprocal Lattice.** The Bragg Diffraction Law. Reciprocal Lattice. Fourier Analysis of Scattered Wave. Reciprocal Lattice Vectors. Diffraction Conditions. Laue Equations. Brillouin Zones. Reciprocal Lattice to Cubic Lattice. Reciprocal Lattice to Face-Centered Cubic Lattice. Reciprocal Lattice to Body-Centered Cubic Lattice. Fourier Analysis of the Basis. Structure Factor of Body-Centered Cubic Lattice. Structure Factor of Face-Centered Cubic Lattice. Atomic Form Factor. Problems. **Band Structures.** Introduction. Free Electron Fermi Gas. Single Electron Model. Fermi Sphere. Density of States. Fermi Distribution Non-Interacting Electrons in a Periodic Potential. Definition of Periodic Potential. Bloch Theorem. Band Index. Fermi Surface. Kronig-Penney Model. Energy Bands in 1D lattice. Nearly Free Electrons in a Weak Periodic Potential. General Approach to Schrodinger Equation. Energy Levels near a single Bragg Plane. Energy Bands in a 1D lattice. Tight-Binding Model. General Approach. Energy Bands in a 1D Lattice. Energy Bands in Three

	Dimensions. High Symmetry Points. Energy Bands in a Cubic Lattice. Energy Bands in a Body-Centered Cubic Lattice. Energy Bands in a Face-Centered Cubic Lattice. Orthogonalized Plane-Wave. Pseudopotential. **Semiconductor Structures.** Introduction. Silicon, Germanium and Gallium Arsenide. Covalent Bonding. Crystal Structure. Energy Bands. Band Gap. Motion of Electron Wave in an Energy band. Semiclassical Equations of Motion. Dynamical Effective Mass. Parabolic Approximation. Carrier Concentration at Thermal Equilibrium. Intrinsic Semiconductor. Donors and Acceptors. Extrinsic Carriers Concentration. Problems. **Boltzmann's Transport Equation.** The Electron Distribution Function. Equation of Motion. Steady-state Transport. Relaxation Time Approximation. Electrical and Thermal Transport. Isothermal Electrical Conductivity. Thermo-electric Transport. Thermal Conductivity **Low Dimensional Systems.** Introduction. 2D Quantum Heterostructures. Finite Quantum Well. Quantized Energy Levels. Density of States. Influence of Effective Mass. 2D Graphene. Crystal Structure. Brillouin Zones. Energy Bands. Density of States. Quantum Wire. Energy Bands. Density of States. GaAs Nanowire: Subbands and Probability Density. Quantum dot. Density of States. Energy Levels in Spherical Potential Well. Thermal vs Nonthermal Distribution. Population Statistics: Rate Equations vs Random Population. Phosphorene and Black Phosphorus. Crystal Structure. Primitive Cell and Brillouin Zone. Energy Bands and Density of States. Field-Effect Transistors. Photodetectors.
Books and bibliography	• N. W. Ashcroft and N. D. Mermin – Solid State Physics, Cencage. • C. Kittel – Introduction to Solid State Physics, John Wiley & Sons Inc. • S. M. Sze – Physics of Semiconductor Devices, Wiley-Interscience.
Additional materials	

Work schedule			
Total	Lectures	Hands on (Laboratory, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
Hours			
150	40	15	95
ECTS			
6	5	1	

Teaching strategy	
Expected learning outcomes	
Knowledge and understanding on:	The course allows students to acquire advanced knowledge on the structure of matter and on the electronic, thermal and optical properties of solid-state systems by using rigorous quantum models. In order to apply the acquired knowledge to the fields of interest in solid-state physics, the student will acquire methods for a critical elaboration of concepts to be extended to more complex problems of solid-state physics.
Applying knowledge and understanding on:	The theoretical models studied in the course will be combined with an in-depth investigation of experimental and theoretical techniques typically used to analyze

	the structure and symmetries of crystalline solids, as well as to study their thermal, electrical and optical properties. By integrating with concepts acquired in the Condensed Matter Physics course, this knowledge will constitute a solid basis for understanding the principle of operation of electronic, optoelectronic and quantum devices.

Soft skills	• *Making informed judgments and choices*
	  ○ Capability to solve problems using quantum formalism
	  ○ Capability to search in the scientific literature for theoretical models to study and analyse phenomena related to solid-state physics
	• *Communicating knowledge and understanding*
	  ○ Capability to discuss models and mechanics using an appropriate scientific language.
	• *Capacities to continue learning*
	  ○ Capability to critically evaluate the need of use semi-classical or quantum models to address some problems and describe experiments concerning the electronic properties of crystals and low dimensional systems.

Assessment and feedback	
Methods of assessment	Oral exam (100%)
Evaluation criteria	• *Adequate comprehension and global knowledge of concepts and arguments described throughout the course.* • *Capability to discuss models and mechanics introduced in the course.*
Criteria for assessment and attribution of the final mark	• 30 cum laude: complete, in-depth and critical knowledge of the topics, excellent language skills, full ability to apply knowledge to solve the proposed problems; • 28 - 30: complete and in-depth knowledge of the topics, excellent language properties, able to apply knowledge to solve the proposed problems; • 24 - 27: good knowledge of the topics, good language skills, good ability to correctly apply most of the knowledge to solve the proposed problems; • 20 - 23: adequate knowledge of the topics but limited mastery of the same, satisfactory language properties, more than sufficient ability to apply knowledge to solve the proposed problems; • 18 - 19: basic knowledge of the main topics, basic knowledge of technical language, sufficient ability to apply the acquired basic knowledge; • <18 Insufficient: the knowledge of the topics covered during the course is not acceptable.
Additional information	