COURSE OF STUDY *Physics (LM-17)*

ACADEMIC YEAR *2024-2025*

ACADEMIC SUBJECT *Condensed Matter Physics*

General information	
Year of the course	1st
Academic calendar (starting and ending date)	1st semester: September - December 2024
Credits (CFU/ECTS):	6
SSD	FIS/03
Language	English
Mode of attendance	Compulsory

Professor/ Lecturer	
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Department and address	Department of Physics, University of Bari "A. Moro", via Amendola 173, 70125, Bari
Virtual room	Teams - 89eax1h
Office Hours (and modalities: e.g., by appointment, on line, etc.)	Monday 12-13 Thursday 11-13 + or by appointment agreed via email.

Work schedule			
Hours			
Total	Lectures	Hands-on (laboratory, workshops, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
150	32	30	88
CFU/ECTS			
6	4	2	

Learning Objectives	The main objective of the course is to provide the basis for understanding the main properties of condensed matter and its interaction with radiation in the spectral ranges of vibrational and electronic resonances. In addition to the characteristics of bulk solids, particular attention is paid to the properties of surfaces and interfaces both natural and obtained by epitaxial growth techniques. Special attention is placed in the description of quantization effects (e.g. phonons, plasmons) and in the introduction to the soft matter physics. A relevant objective is also the hands-on learning of advanced experimental techniques for the study of surface and dielectric properties of solids using research-grade instrumentation such as atomic force microscopy (AFM), scanning electron microscopy (SEM), Fourier-transform infrared spectroscopy (FTIR).
Course prerequisites	Solid state physics, quantum physics, statistical physics at the level of bachelor degree in physics.

Teaching strategies	Lectures in the teaching room with the aid of a laptop and a projector or a blackboard. Laboratory activities supervised in research grade setups.
Expected learning outcomes in terms of	

Knowledge and understanding on:	o Understanding the scientific method, the nature, and the methods of research in Physics o Knowledge of the structure of matter, with particular attention to condensed matter and photonics applications o Basic and advanced aspects of condensed matter structure o Surface structure and related experimental techniques o Radiation-matter interaction in solids o Soft matter physics
Applying knowledge and understanding on:	o Ability to identify the essential elements of a phenomenon o Ability to use analogy to apply known solutions to new problems (problem solving) o Ability to use analytical and numerical mathematical computation tools o The essential description and the assessment of physical limits of phenomena involving condensed matter or the interaction of light with matter in the condensed state
Soft skills	● *Making informed judgments and choices* o Ability to work with increasing levels of autonomy, including taking responsibility in project planning and managing facilities. o Ability to describe and quantitatively model relevant structural, vibrational, optical and surface properties of condensed matter. o Ability to choose suitable experimental methods to measure relevant structural, vibrational, optical and surface properties of condensed matter ● *Communicating knowledge and understanding* o Competence in communication in Italian and English in advanced fields of Physics o Skills in the exposition of physical phenomena and experimental results using appropriate scientific language ● *Capacities to continue learning* o Acquisition of basic knowledge tools for continuous learning and knowledge updates o Ability to learn and to transfer experimental methods for the assessment of relevant physical properties of matter
Syllabus	
Content knowledge	Order and disorder in condensed matter. Bulk properties of crystals. Fourier analysis and reciprocal lattice. X-ray scattering. Collective effects in solids. The exchange interaction and magnetic order. Magnetic phase transitions. Ferromagnetic domains. Colossal magnetoresistance. Surface structure and crystal growth. Elastic properties of solids. Surface tension in solids. Roughening. Equilibrium crystal shapes. Non-equilibrium crystal growth: molecular beam epitaxy. Experimental methods to measure the structure, the mechanical and electrostatic properties of surfaces with atomic resolution: atomic force microscopy (AFM); scanning electron microscopy (SEM); Reflection high energy electron diffraction (RHEED). Laboratory activity: scanning probe microscopy (AFM). Laboratory activity: scanning electron microscopy (SEM). Classical and quantum waves in solids. Lattice vibrations, acoustic and optical

	modes in three dimensions. Phonons. Neutron diffraction. Dielectric function and its dispersion. Phonon-polaritons. Plasmons. Soft matter physics: complex liquids, colloids, polymers, biopolymers, gels. Phase-changes. Liquid crystals.
Texts and readings	- L. Sander, “Advanced condensed matter physics”, Cambridge, 2009 - A. E. Siegman, “Lasers”, University Science books, 1986 Suggested readings: - Kittel, "Introduction to Solid State Physics", Wiley, 2005. - N. W. Ashcroft, N. D. Mermin, ”Solid state physics”, Thomson Brooks, 1976.
Notes, additional materials	Lecture notes. Laboratory setups manuals
Repository	*MS Teams*

Assessment	
Assessment methods	Oral exam (75%). Laboratory report (25%).
Assessment criteria	● *Knowledge and understanding* o basic principle of condensed matter structure. o phenomena supporting present knowledge of condensed matter structure. o experimental methods to study the properties of solids and surfaces. o successful models describing the condensed state of matter. ● *Applying knowledge and understanding* o capability to discuss the interconnection between individual components of solids and related interaction phenomena ● *Autonomy of judgment* o Identify and compare fundamental physical facts and supporting relevant phenomena ● *Communicating knowledge and understanding* o Mastering physics and scientific communication ● *Communication skills* o Capability of support statements with relevant examples, demonstrating understanding ● *Capacities to continue learning* o Capability to exploit the achieved knowledge and concepts to further studying advanced physics and technological topics
Final exam and grading criteria	*The final grade is assigned on a scale of thirty. The exam is considered passed when the grade is greater than or equal to 18.*
Further information	