University of Gdańsk

Subject card

Subject name and code	Solid State Physics, PG_00182657					
Field of study	Physics					
Date of commencement of studies	October 2025		Academic year of realisation of subject		2025/2026	
Education level	Master's studies		Subject group		Obligatory subject group in the field of study Optional subject group Subject group related to scientific research in the field of study	
Mode of study	full-time studies		Mode of delivery		at the university	
Year of study	1		Language of instruction		Polish	
Semester of study	1		ECTS credits		8.0	
Learning profile	academic		Assessment form		exam	
Conducting unit						
Name and surname of lecturer (lecturers)	Subject supervisor		dr inż. Tadeusz Leśniewski			
	Teachers					
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	30.0	30.0	0.0	0.0	90
	E-learning hours included: 0.0						
Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan		Participation in consultation hours	Self-study		SUM
	Number of study hours	90		0.0	110.0		200

Subject objectives

The aim of the *Solid State Physics* course is to provide students with advanced knowledge of the structure, properties, and phenomena occurring in solids, as well as to develop the ability to apply theoretical models and experimental methods to their description. The course is intended to:

- introduce students to the fundamental concepts and theories of solid state physics (including crystal structure, real and reciprocal space, band theory, superconductivity),
- develop the ability to analyze the results of experimental studies and computer simulations and to interpret them critically in the light of theoretical models,
- prepare students for the conscious use of the scientific method in the study of material properties, taking into account the limitations and approximations of models,
- demonstrate the importance of solid state physics for the development of modern technologies (semiconductor electronics, superconductors, nanostructures, radiation generation and detection).

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[FIZMU2_U09] can work independently or in a team	Can plan and carry out an experimental or simulation project concerning solid state properties, including within teamwork. Can present results in the form of an individual or joint report or presentation, communicating conclusions clearly.	[SU2] presentation/project/paper/report [SU3] text preparation/written work
	[FIZMU2_U03] is able to make a critical analysis of the results of measurements, observations or theoretical calculations along with the assessment of the accuracy of the results	Can analyze and interpret the results of experimental studies and theoretical calculations concerning solids, taking into account uncertainties and measurement limitations. Can compare experimental and simulation results with the predictions of theoretical models and assess their consistency. Critically evaluates the adequacy and applicability limits of models used to describe phenomena in solid state physics. Is able to synthesize data from various sources (experiments, simulations, literature) to formulate well-justified conclusions.	[SU2] presentation/project/paper/report [SU3] text preparation/written work
	[FIZMU2_K01] knows the limitations of his own knowledge and skills; can formulate questions precisely; understands the need for further education and other	Identifies own knowledge gaps, formulates research questions, and strives for self-education in solid state physics. Can prepare a report or presentation, critically reflecting on results and indicating areas requiring further study.	[SK2] presentation/project/paper/report [SK3] text preparation/written work
	[FIZMU2_W01] has advanced knowledge of general physics and in-depth knowledge of various areas of physics; knows the history of the development of physics and its importance for the progress of exact and natural sciences, cognition of the world and social development	Explains fundamental concepts of solid state physics such as: Bravais lattice, phonon, energy band, electron hole, Cooper pair. Knows the physical principles determining the nature of bonding and can relate them to material properties. Knows the basic theories describing solids (including band theory, superconductivity theory) and their significance for the development of physics and technology. Understands the links between atomic physics, statistical physics, electromagnetism, and solid state physics. Understands the importance of solid state physics for technological development (semiconductors, superconductors).	[SW4] test/exam - oral or written [SW3] text preparation/written work

	Course outcome	Subject outcome	Method of verification
	[FIZMU2_U01] is able to apply the scientific method in solving physical problems, conducting experiments and reasoning	Knows and applies theoretical models describing the properties of solids and understands their significance and limitations. Can interpret physical phenomena in solids in the light of modern theories and experimental results. Analyzes experimental and simulation data, draws conclusions consistent with the scientific method, and provides their critical assessment. Knows examples of the application of the scientific method in the development of solid state physics and can indicate their significance for science and technology.	[SU3] text preparation/written work [SU4] test/exam - oral or written
	[FIZMU2_W03] knows experimental, observational and numerical techniques to plan and perform a complex physics experiment or computer simulation	Can plan and conduct an experiment or simulation in the field of X-ray diffraction, Raman spectroscopy, charge transport, or thermal conductivity, and interpret the results. Uses numerical tools to visualize crystal structures, simulate band structures, and analyze data. Integrates experimental data with simulation results to draw consistent conclusions about material properties.	[SW2] presentation/project/paper/ report [SW3] text preparation/written work
	[FIZMU2_K02] is aware of the conclusive role of experiment in the verification of physical theories; is aware of the scientific method in the accumulation of knowledge	Understands the importance of experimental studies – structural, spectroscopic, thermal, transport, and radiation interaction – for verifying theoretical models in solid state physics. Can critically assess the limitations and applicability of theoretical models in relation to experimental results. Is aware of the complexity and approximate nature of models describing solids. Can indicate examples where experiment disproves or modifies established models (e.g., specific heat of dielectrics, high-temperature superconductivity).	[SK3] text preparation/written work [SK4] test/exam - oral or written

Subject contents	**Structure and Symmetry of Solids** • types of crystal bonding, • crystal structures and Bravais lattices, • X-ray diffraction in crystals, • reciprocal lattice, • crystal lattice defects (point, line, surface, bulk). **Crystal Growth and Structures** • nucleation and crystal growth mechanisms, • methods of crystal growth, • fabrication of crystalline layers and low-dimensional structures. **Lattice Vibrations and Thermal Properties** • lattice vibrations, phonons, • Raman effect, • specific heat of solids (Einstein and Debye models), • thermal conductivity of crystals. **Electrical Properties of Solids** • energy structure (phenomenological and quantum approach), • Fermi electron gas, • conduction models: Drude and quantum, • Bloch functions and energy bands in reciprocal space, • dielectric and magnetic properties. **Semiconductors and Insulators** • charge carrier dynamics (electrons and holes), effective mass, • intrinsic semiconductors thermodynamic equilibrium, density of states, mass action law, • doped semiconductors donor and acceptor states,

	• Hall effect in semiconductors, • semiconductor junctions, • advanced structures: semiconductor layers, nanostructures. **Localized States and Radiation Interactions** • direct and indirect band gaps, internal photoelectric effect, • defects and impurities: localized states, electron and hole traps, • interaction of electromagnetic radiation with solids: absorption, luminescence. **Superconductivity** • basic concepts and London equations, • Cooper pairs and elements of BCS theory, • critical temperature and high-temperature superconductors.
Prerequisites and co-requisites	Prerequisites • Knowledge of the basics of general physics (mechanics, thermodynamics, electrodynamics, quantum physics), • Knowledge of the basics of higher mathematics (mathematical analysis, linear algebra, differential equations), • Basic knowledge of general and physical chemistry (atomic structure, chemical bonding). Additional requirements (recommended) • Ability to use numerical tools and computational packages, • Familiarity with basic experimental methods in solid state physics, • Familiarity with spectroscopic research methods.

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
reports	51.0%	20.0%
written/oral exam	51.0%	50.0%
written assessment	51.0%	30.0%

Recommended reading

Basic literature	**C. Kittel** *Introduction to Solid State Physics*, Wiley. **N.W. Ashcroft, N.D. Mermin** *Solid State Physics*,
Supplementary literature	**F.A. Cotton** *Chemical Applications of Group Theory*, Wiley
eResources addresses	

Example issues/ example questions/ tasks being completed	Exam Topics Solid State Physics 1. Chemical bonding in solids 2. Crystal structures (systems, Bravais lattices, Miller indices) 3. Reciprocal lattice and X-ray diffraction (Bragg and Laue conditions) 4. Diffraction methods for crystal structure determination 5. Fermi electron gas and density of states 6. FermiDirac statistics 7. Band theory and nearly free electron model 8. Intrinsic and doped semiconductors, effective mass, holes 9. pn junction and its applications 10. Hall effect 11. Lattice vibrations and phonons 12. Specific heat of solids (Einstein and Debye models) 13. Superconductivity (phenomenon, London equations, Cooper pairs, BCS theory, high-temperature superconductors)
Work placement	Not applicable