COURSE DESCRIPTION CARD - SYLLABUS

Course name
Fundamentals of Condensed Matter Physics [S1FT2>PFFS]

Course

Field of study
Technical Physics

Year/Semester
2/4

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
45

Laboratory classes
0

Other
0

Tutorials
30

Projects/seminars
0

Number of credit points

5,00

Coordinators

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Lecturers

Prerequisites

Basic knowledge of experimental physics, quantum and atomic physics and knowledge of mathematical methods. The ability to solve problems in physics at the level of experimental physics, quantum and atomic physics, the ability to obtain information from the indicated sources. Understanding the need to expand one's competences, understanding the need to make decisions for the benefit of the academic community.

Course objective

1. Acquainting students with the basic physical phenomena related to the crystal structure of materials, structure defects, classification of materials and their properties, and their theoretical description at the academic level. 2. Acquainting with the knowledge of the basic issues including the methodology of experimental research used in the characterization of the condensed phase. 3. Introducing students to the area of applications of materials with the structure of solids and their importance and role in modern technology and nanotechnology. 4. Developing students' ability to solve problems related to condensed matter based on the acquired knowledge.

Course-related learning outcomes

Knowledge:

1. She/he has knowledge of the condensed matter physics necessary to understand the laws governing phenomena occurring in condensed matter
2. She/He has knowledge of the physical properties of condensed matter (classical and quantum description) and knows the methodology of condensed matter research
3. She/he knows and understands the principle of operation of measuring devices and research apparatus using elements and systems made of condensed matter
4. She/He knows the current state of advancement and is aware of the latest development trends in the field of functional materials and nanotechnology and knows the areas of their application

Skills:
1. She/he can formulate simple conclusions based on the obtained results (calculations and measurements), use with understanding of the indicated sources of knowledge (list of literature) and acquire knowledge from other sources, especially electronic bibliographic sources
2. She/He can use the basic devices of the experimental infrastructure used for research on condensed matter in accordance with the requirements of occupational health and safety
3. She/he can select materials with appropriate physico-chemical properties for laboratory and technological applications

Social competences:
1. She/He can solve problems on his own, as well as cooperate within a team
2. She/he can think and act creatively
3. She/He understands the importance and contribution of various branches of science, technique and technology, including condensed matter physics, in the development of civilization and society, understands the need to formulate and transfer this information to the society

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Form of evaluation
Written exam
5,0 (very good) A <90-100%
4,5 (good plus) B <80-90%
4,0 (good) C <70-80%
3,5 (satisfactory plus) D <60-70%
3,0 (satisfactory) E <50-60%
2,0 (unsatisfactory) F <0-50%

Tests (2 tests/sem.)
Assessment of the student's skills at the blackboard
5,0 (very good) A <90-100%
4,5 (good plus) B <80-90%
4,0 (good) C <70-80%
3,5 (satisfactory plus) D <60-70%
3,0 (satisfactory) E <50-60%
2,0 (unsatisfactory) F <0-50%

Assessment of the student's competences acquired during the lecture and exercises
5,0 (very good) A <90-100%
4,5 (good plus) B <80-90%
4,0 (good) C <70-80%
3,5 (satisfactory plus) D <60-70%
3,0 (satisfactory) E <50-60%
2,0 (unsatisfactory) F <0-50%

Programme content

1. Basic quantum problems.
2. Chemical bonds.
3. Crystalline structure of materials.
4. Investigations of crystal structure.

5. Crystal lattice imperfections. Point defects and dislocations. Surface defects.
6. Quasicrystals.
7. Lattice vibrations. Phonons.
8. Specific heat of solids. Models: Classic, Einstein and Debye.
9. Scattering methods for studies of solids: Raman and Brillouin spectroscopy.
10. Free electron Fermi gas.
11. Band theory of solids.
12. Semiconductors.

Course topics

1. Basic quantum problems - Schrödinger equation, free particle motion, potential well, potential barrier, tunnel effect, linear harmonic oscillator, hydrogen-like atom.
2. Chemical bonds. Properties of crystals with covalent, ionic, metallic, hydrogen and van der Waals bonds.
3. Crystalline structure of materials. Crystal lattice and lattice translation vectors. Crystal structure. Bravis lattice. Packing factor. Miller indices of nodes, directions and planes, elements of crystal symmetry.
4. Investigations of crystal structure. Neutron, electron and X-ray diffraction. Bragg and Laue"s law. Reciprocal lattice. Ewald"s construction. Diffraction methods for studying the structure of crystals (Laue, rotating crystal, powder method).
5. Crystal lattice imperfections. Point defects and dislocations. Surface defects. Burgers vector. Stress field and dislocation energy.
6. Quasicrystals. Penrose tilings. Features and properties of quasicrystals.
7. Lattice vibrations. Adiabatic, electron and harmonic approximations. Vibrations of one-dimensional chain with one and two kinds of atoms. Acoustic and optical phonons - dispersion relations.
8. Specific heat of solids. Models: Classic, Einstein and Debye.
9. Scattering methods for studies of solids: Raman and Brillouin spectroscopy.
10. Free electron Fermi gas. Drude"s model. Heat capacity of electron gas. Density of states function and Fermi energy. Fermi-Dirac distribution function. Electronic heat capacity.
11. Band theory of solids - adiabatic and one-electron approximation, strongly bonded electron approximation, weakly bonded electron approximation, energy bands, Brillouin zone, effective mass.
12. Intrinsic and doped semiconductors. Direct and indirect band gap. p-n junction.

Teaching methods

Lecture: multimedia presentation, illustrated with graphic examples, animations and films.
Exercises: blackboard classes; multimedia presentation of selected issues; solving of example tasks for each topic; individual solving of tasks given by the tutor.

Bibliography

Basic:
1. Ch. Kittel, Wstęp do fizyki ciała stałego, Wydawnictwo Naukowe PWN, Warszawa 2012.
2. H. Ibach, H. Lüth, Fizyka Ciała Stałego, Wydawnictwo Naukowe PWN, Warszawa 1996.
3. N.W. Ashcroft, N.D. Mermin, Fizyka Ciała Stałego, Państwowe Wydawnictwo Naukowe, Warszawa 1986.
4. Z. Trzaska Durski, H. Trzaska Durska, Podstawy krystalografii strukturalnej i rentgenowskiej, Wydawnictwo Naukowe PWN, Warszawa 1994.
5. J. Garbarczyk, Wstęp do fizyki ciała stałego, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2000.

Additional:
1. M. Drozdowski i inni, Spektroskopia ciała stałego, Wydawnictwo Politechniki Poznańskiej, 2001.
2. G. Turrell, Infrared and Raman spectra of crystals, Academic Press Inc., London 1972.

Breakdown of average student's workload

	Hours	ECTS
Total workload	125	5,00
Classes requiring direct contact with the teacher	77	3,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	48	2,00