GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Quantum Materials, PG_00072604		
Field of study	Technical Physics, Materials Engineering, Mathematics, Materials Engineering, Nanotechnology, Nanotechnology, Materials Engineering		
Date of commencement of studies	October 2025	Academic year of realisation of subject	2026/2027
Education level	second-cycle studies	Subject group	Optional subject group
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	2	Language of instruction	English
Semester of study	3	ECTS credits	1.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Institute of Nanotechnology and Materials Engineering -> Faculty of Applied Physics and Mathematics -> Faculties of Gdańsk University of Technology		
Name and surname of lecturer (lecturers)	Subject supervisor	prof. dr hab. inż. Tomasz Klimczuk	
	Teachers	prof. dr hab. inż. Tomasz Klimczuk	

Lesson types

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	15.0	0.0	0.0	0.0	0.0	15

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	15	2.0	8.0	25

Subject objectives

The aim of the course is to familiarize students with synthesis methods and the physics of quantum materials.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_W101] is able to make an in-depth identification of key objects and phenomena related to the field of study, as well as theories that describe them and applicable analytical and design methods	The student knows and understands, at an advanced level, the fundamental physical phenomena occurring in quantum materials, as well as the theories and methods used for their characterization	[SW1] Assessment of factual knowledge
[K7_U101] is able to formulate complex research problems and adopts appropriate methods, obtaining innovative solutions, cooperating with other people, both as a leader and a team member	The student is able to formulate research problems concerning the properties of quantum materials, select appropriate measurement methods and theoretical models, and analyse and interpret the results obtained.	[SU3] Assessment of ability to use knowledge gained from the subject
[K7_K101] acknowledges the importance of knowledge related to the field of study in solving cognitive and practical problems, critically assessing the information obtained	The student is prepared to critically evaluate information and research results concerning quantum materials and recognizes the importance of knowledge in the field of materials physics for solving cognitive and practical problems	[SK3] Assessment of ability to organize work

<table>
<tr><td>Subject contents</td><td>Course content – lecture

1. Introduction to quantum materials. 2. Phase diagrams. 3. Synthesis of polycrystalline materials. 4. Crystal growth methods for intermetallic materials: flux growth, chemical vapor transport, physical vapor transport.

5. Paramagnetism the Curie-Weiss law, calculation of the effective magnetic moment, determination of the Pauli temperature. 6. Diamagnetism, antiferromagnetism, ferromagnetism. 7. Measurement of specific heat using the relaxation method. 8. Dulong-Petit law, Einstein and Debye models. 9. Specific heat measurements determination of the Sommerfeld coefficient and Debye temperature. 10. Electrical resistance measurements for metals methods used, theoretical models. 11. Classical, quantum, and anomalous Hall effects. 12. Hall effect measurements - examples. 13. Introduction to superconductivity. 14. Superconducting materials. 15. Exotic superconductors</td></tr>
<tr><td>Prerequisites and co-requisites</td><td>Basic knowledge of mathematics, physics, and chemistry, including familiarity with symbols of elements, the ability to manipulate of the mathematical formulas, understanding of graphs, and analytical thinking skills.</td></tr>
<tr><td>Assessment methods and criteria</td><td><table><tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr><tr><td>passing exam</td><td>60.0%</td><td>100.0%</td></tr></table></td></tr>
<tr><td>Recommended reading</td><td><table><tr><td>Basic literature</td><td>1. John Singleton, Band Theory and Electronic Properties of Solids, Oxford Master Series in Condensed Matter Physics, 2001 2. Mary Anne White, Properties of Materials, Oxford University Press 1999;</td></tr><tr><td>Supplementary literature</td><td>1. William D. Callister, Jr. Materials Science and Engineering an Introduction, John Wiley & Sons;</td></tr><tr><td>eResources addresses</td><td></td></tr></table></td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td>1. Compare the anomalous and classical Hall effects. 2. Propose the technique and details for growing CaBi2 crystals. 3. Discuss the methods for measuring electrical resistance and the Hall effect in metals.</td></tr>
<tr><td>Practical activites within the subject</td><td>Not applicable</td></tr>
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