GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Quantum mechanics, PG_00071197		
Field of study	Nanotechnology		
Date of commencement of studies	October 2026	Academic year of realisation of subject	2026/2027
Education level	second-cycle studies	Subject group	Obligatory subject group 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	6.0
Learning profile	general academic profile	Assessment form	exam
Conducting unit	Department of Solid State Physics -> Faculty of Applied Physics and Mathematics -> Faculties of Gdańsk University of Technology		
Name and surname of lecturer (lecturers)	Subject supervisor	prof. dr hab. inż. Jarosław Rybicki	
	Teachers		

Lesson types

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	30.0	30.0	0.0	0.0	0.0	60
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	60	2.0	88.0	150

Subject objectives

The aim of the course is to present quantum mechanics as the foundation for describing phenomena on the nanoscale. The course develops concepts introduced in modern physics (the idea of quanta, wave-particle duality, wave function and its probabilistic interpretation), embedding them in advanced mathematical apparatus (Hilbert space, linear operators, self-adjoint, unitary, matrix elements, Dirac notation, etc.). The lecture will present algebraic methods (creation and annihilation operators for a harmonic oscillator, raising and lowering operators for angular momentum, hydrogen-like atom, etc.), approximate methods (variational, WKB, time-dependent and time-independent perturbation theory, electron and molecule spin, Hartree-Fock methods, etc.), Klein-Gordon relativistic equations, and the Dirac equation for electrons.Komputerowe modelowanie i projektowanie materiałów, "Symulacje kwantowe z użyciem cząstek", Teoretyczne podstawy nanotechnologii).

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_W02] has in-depth, theoretically grounded and detailed knowledge of phenomena, methods, and theories related to nanotechnology, as well as of related and allied fields of science or engineering	Quantum mechanics is the basic tool to describe nano-scale phenomena.	[SW1] Assessment of factual knowledge
[K7_U05] is able to plan and carry out theoretical and numerical calculations as well as simulations of phenomena and processes, critically analyze their results, draw conclusions, and formulate well-founded opinions in nanotechnology and related physical and natural sciences	Mathematical description of a variety of nano-scale phenomena will be highlighted	[SU3] Assessment of ability to use knowledge gained from the subject [SU4] Assessment of ability to use methods and tools
[K7_U06] is able to apply acquired specialist knowledge to problems in other physical, natural, or technical sciences and to critically analyze and evaluate the functioning of the adopted solutions	Criticam evaluation of theorecital results and range of their applicability will be highlighted	[SU2] Assessment of ability to analyse information

Subject contents	Course content – lecture A linear vector space and a scalar product. The Hilbert space. The concept of a linear operator on the Hilbert space. Self-adjoined operators. The eigenvalue problem (eigenequation, eigenvectors and eigenvalues). The the postulate of quantum mechanics. The stationary Schrodinger equation. A particle in an infinitely deep potential well. The quantum one-dimensional harmonic oscillator. The creation and annihilation operators for a one-dimensional harmonic oscillator, give and derive their main commutation properties. Tthe Heisenberg uncertainty principle for any self- adjoined operators A and B. The probability current density and equation. Tthe Ehrenfest theorem. The variational method. The WKB method. Tthe conditions of Sommerfeld quantization. The stationary perturbation theory. Time dependent parturbations. Elemaenary scattering theory. The Klein-Gordon equation, The Dirac equation. Course content – exercises The problem-solving classes are aimed at developing the skills of practical application of quantum mechanics formalism through independent solving of computational and conceptual problems, analysis of quantum models relevant to nanotechnology, and physical interpretation of the obtained results.		
Prerequisites and co-requisites	Knowledge of mathematics and physics at the level of the first two years of study, in particular, a good knowledge of the following branches of mathematics and physics: differential calculus, integral calculus, probability theory, classical mechanics, electrostatics and magnetism, basics of modern physics.		
Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	written exam in theory	50.0%	50.0%
	two written tests in problem solving	50.0%	50.0%
Recommended reading	Basic literature	Ramamurti Shankar, Principles of Quantum Mechanics, Plenum Press, 2011, Chapters 1. Mathematical introduction 4. The postulates - a general discussion 5. Simple problems in one dimension 6. The classical limit 7. The harmonic oscillator 9. The Heisenberg relations 16. Variational and WKB methods 17. Time-independent perturbations 18. Time-dependent perturbations Griffiths, Chapter 4	
	Supplementary literature	Chapers of various handbooks to be selected by individual students	
	eResources addresses		

Example issues/ example questions/ tasks being completed	1. Discuss analogies and differences between classical and quantum mechanics. 2. What is the probability density function? What properties does it have? 3. Present the time-dependent Schrödinger equation. 4. Discuss the statistical interpretation of the wave function. 5. Formulate Heisenberg's uncertainty principle for position and momentum operators and discuss its consequences. 6. Discuss the procedure used for solving the time-dependent Schrödinger equation. 7. Present the time-independent Schrödinger equation. 8. Explain why the stationary states are so important in quantum mechanics. 9. Solve the time-independent Schrödinger equation for an infinite potential well that extends between points 0 and a. 10. Express the Hamiltonian of the quantum harmonic oscillator in terms of ladder operators. 11. Explain what is the wave packet? What is the significance of this concept in quantum mechanics? 12. What does tunnelling mean? What are the consequences of this phenomenon? 13. What is the physical meaning of transmission T and reflection R coefficients? How are they defined? How are they related? 14. Discuss the properties of operators used in quantum mechanics. 15. Discuss Dirac notation. 16. Explain what is eigenproblem, eigenvector and eigenvalue. Give examples of eigenproblems in quantum mechanics. 17. Starting with Schwarz inequality derive the generalized uncertainty principle. 18. What are orbitals? What are shells? What are subshells? How do these concepts are related to quantum numbers n, l and m? 19. Discuss quantization of angular momentum. 20. For the given wave function calculate the expectation values. Check if Heisenberg's uncertainty principle is satisfied. ETC, ETC, ...
Practical activites within the subject	Not applicable

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