GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Introduction to quantum mechanics, PG_00063685		
Field of study	Nanotechnology		
Date of commencement of studies	October 2025	Academic year of realisation of subject	2025/2026
Education level	second-cycle studies	Subject group	Specialty 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	English
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 -> Wydziały Politechniki Gdańskiej		
Name and surname of lecturer (lecturers)	Subject supervisor	prof. dr hab. inż. Jarosław Rybicki	
	Teachers	dr inż. Szymon Winczewski prof. dr hab. inż. Jarosław Rybicki	

Lesson types and methods of instruction	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	5.0	85.0	150

Subject objectives	The aim of the course is to familiarize students with the basics of quantum mechanics, which is the basis for a theoretical description of phenomena occurring at the atomic level. The subject is also aimed at preparing students for further education in the field of theoretical description and modeling of nanometer scale systems (courses such as: Computer modelling and desing of materials, "Quantum simulations with particles", Theoretical basis of nanotechnology).

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[K7_W02] has enhanced, theoretically supported, detailed knowledge of selected branches of nanotechnology and, according to the needs, within the scope of related fields of science and technology.	The student has knowledge of quantum mechanics, which is a branch of modern physics. The student is able to present the laws of quantum mechanics. The student knows how to use the mathematical formalism of quantum mechanics to solve exemplary problems.	[SW3] Assessment of knowledge contained in written work and projects [SW1] Assessment of factual knowledge
	[K7_W03] has general knowledge on current development directions and discoveries in physics, chemistry, technology and applications of nanostructures.	The student is able to independently study the given literature. The student is able to find content about issues discussed during the lecture, in order to re-study them in depth.	[SW3] Assessment of knowledge contained in written work and projects [SW1] Assessment of factual knowledge
	[K7_U06] can plan and conduct theoretical and numerical calculations, simulations of phenomena and processes, critically analyze their results, draw conclusions and formulate reasoned conclusions – within their specialization.	The student is able to present clearly his own solution to the given problem during tutorial classes and consultations. By tracking and analyzing the course of another person's solution he is able to assess its correctness and indicate mistakes made.	[SU3] Assessment of ability to use knowledge gained from the subject [SU4] Assessment of ability to use methods and tools [SU5] Assessment of ability to present the results of task [SU1] Assessment of task fulfilment
	[K7_U07] can apply the obtained specialist knowledge to the problems within exact sciences, natural or technical sciences.	The student knows which of the phenomena and processes taking place on the atomic scale require the use of the quantum-mechanical description.	[SU2] Assessment of ability to analyse information [SU3] Assessment of ability to use knowledge gained from the subject

Subject contents	1) Introduction a) history of quantum mechanics (years 1900-1930), b) analogies and differences in classical and quantum description, c) areas of quantum mechanics applications, 2) Basic concepts in the probability theory (a quick review) a) discrete variables, continuous variables, b) probability, probability density function, c) mean (average) value, deviation, variance, standard deviation, 3) Basics of quantum mechanics a) time-dependent Schrödinger equation, b) wave function, c) statistical interpretation of wave function, d) normalization of wave function, e) position and momentum operators, f) Ehrenfest theorem for position and momentum operators, g) correspondence principle, h) the importance of measurement, i) collapse of wave function, j) uncertainty principle, 4) Method for solving time-dependent Schrödinger equation a) separation of variables, b) stationary states and their properties, c) general solution as a linear combination of the stationary states, d) initial condition, e) time-independent Schrödinger equation, 5) Infinite square well a) problem formulation, b) solution of time-independent Schrödinger equation, c) form of the solutions and their properties, 6) Harmonic oscillator a) problem formulation, b) the importance of the problem, c) algebraic method (ladder operators, commutator of two operators, commutation relations), d) form of the solutions and their properties, e) analytic method (dimensionless variables, power series method, Hermite polynomials), 7) Free particle a) problem formulation, b) plane waves, c) wave packet, d) phase velocity, group velocity, 8) Dirca delta function potential a) bounded states and scattering states, b) problem formulation, c) form of the solutions and their properties, d) transition and reflection, 9) Finite square well a) problem formulation, b) form of the solutions and their properties, c) transition and reflection, 10) Formalism of quantum mechanics a) Hilbert space, b) inner product, c) Schwarz inequality, d) observables, e) Hermitian operators, f) eigenvalue problem (equation), eigenfunctions (eigenvectors), eigenvalues, g) general uncertainty priciple (for two operators, A and B), h) Dirac notation,

	11) Hydrogen atom a) problem formulation, b) Schrödinger equation in spherical coordinates, c) separation of variables, angular equation and radial equation, d) solution of the angular equation, associated Legendre polynomials, spherical harmonics, e) solution of the radial equation, associated Laguerre polynomials, f) quantum numbers, shells, subshells, orbitals, 12) Angular momentum a) angular momentum operator, b) commutation relations, c) ladder operators for angular momentum, d) quantization of angular momentum,
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	(see table below)

Subject passing criteria	Passing threshold	Percentage of the final grade
two written tests in problem solving	50.0%	50.0%
written exam in theory	50.0%	50.0%

Recommended reading		
	Basic literature	David J. Griffiths, Introduction to quantum mechanics, 2nd edition, Pearson Prentice Hall, 2005.
	Supplementary literature	Ramamurti Shankhar, Principles of quantum mechanics, Plenum Press, 2011.
	eResources addresses	Adresy na platformie eNauczanie:

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.
Work placement	Not applicable