GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Quantum mechanics, PG_00037290		
Field of study	Technical Physics		
Date of commencement of studies	October 2023	Academic year of realisation of subject	2025/2026
Education level	first-cycle studies	Subject group	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	3	Language of instruction	Polish
Semester of study	5	ECTS credits	5.0
Learning profile	general academic profile	Assessment form	exam
Conducting unit	Department of Theoretical Physics and Quantum Computing -> Faculty of Applied Physics and Mathematics -> Faculties of Gdańsk University of Technology		
Name and surname of lecturer (lecturers)	Subject supervisor	prof. dr hab. Marek Czachor	
	Teachers	prof. dr hab. Marek Czachor	

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

eNauczanie source address: https://enauczanie.pg.edu.pl/moodle/course/view.php?id=14412

Moodle ID: 30725 Mechanika Kwantowa - Kopia - Nowy https://enauczanie.pg.edu.pl/moodle/course/view.php?id=30725

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	60.0	125

Subject objectives

Introduction to basic structures of quantum mechanics

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K6_W02] Has systematized knowledge of the basics of physics, including mechanics, thermodynamics, electricity and magnetism, optics, atomic and particle physics, solid-state physics, nuclear and elementary particle physics.	Quantum mechanics forms a common element of many branches of science and thus helps to see them all in a unified way.	[SW1] Assessment of factual knowledge
[K6_U02] Can analyze and solve simple scientific and technical problems, based on possessed knowledge, using analytical, numerical, simulation and experimental methods.	Student: Derives basic properties of the Schroedinger equation Solves Schroedinger equation for harmonic oscillator and 1/r potential by creation-annihilation operator techniques Derives basic properties of orbital angular momentum and its eigenproblems Derives properties of the tensor produt for the case of n q-bits	[SU1] Assessment of task fulfilment

<table>
<tr><td>Subject contents</td><td>Course content – lecture
1. Introduction to quantum structures in classical systems (Schrödinger and Heisenberg equations, commutators, complex representation of states, rules of conservation of scalar products - all of these as structures appearing in classical mechanics).

2. Methods for solving the Schrödinger equation using matrix examples.

3. Probabilistic interpretation of quantum states. Quantum random variables and the spectral theorem. The principle of superposition.

4. Tensor product using matrix examples.

5. Elements of quantum cryptography and quantum gates. Interferometers as 2x2 problems, the Elitzur-Vaidman paradox.

6. Infinite potential well as an infinite-dimensional example - the role of boundary conditions.

7. Quantum harmonic oscillator (creation/annihilation operator method, coherent states). Momentum representation.

8. Superpotential method applied to harmonic oscillator and 1/r potential.

9. Uncertainty principle for standard deviations. Coherent states minimize the uncertainty principle.

10. Conservation laws and symmetries - classical and quantum versions. Continuity equation for probability current.

11. Greater number of degrees of freedom. The two-body problem.

12. Orbital angular momentum and spin.

13. Hydrogen atom supplementary material for independent study, lectures in mp4 format and links to other materials on the hydrogen atom available on the e-Nauczanie platform

Course content – exercises
1. Bra and ket bases. Bases in finite-dimensional spaces. Change of basis.

2. Matrix Schrödinger equation. Solution using the spectral theorem.

3. Tensor products. Entangled states, singlet state, EPR correlations.

4. Probabilities: several different methods of calculation.

5. Creation and annihilation operator algebra. Various excited states of a 1D oscillator in position representation.

6. Uncertainty principles for various observables and states.

7. Simple interferometric systems (Mach-Zehnder interferometer in various configurations, quantum optics elements in matrix form).

8. Elements of angular momentum algebra. Representations and relationships between observables and generators using simple examples</td></tr>
<tr><td>Prerequisites and co-requisites</td><td>Theoretical mechanics and mathematical methods of physics</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>Oral exam</td><td>50.0%</td><td>50.0%</td></tr>
<tr><td>Practical exercise</td><td>50.0%</td><td>50.0%</td></tr>
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<tr><td>Recommended reading</td><td><table>
<tr><td>Basic literature</td><td>I.Białynicki-Birula i in., Teoria kwantów, PWN, 1994 R. Schankar, Mechanika kwantowa, PWN, 2005 L. Landau, E.Lifszyc, Mechanika kwantowa - teoria nierelatywistyczna, PWN, 1980</td></tr>
<tr><td>Supplementary literature</td><td>No requirements</td></tr>
<tr><td>eResources addresses</td><td></td></tr>
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<tr><td>Example issues/ example questions/ tasks being completed</td><td>Qubinary coding

Superpotential</td></tr>
<tr><td>Practical activites within the subject</td><td>Not applicable</td></tr>
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