POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Quantum Physics [S1FT2>FK]

Course

Field of study
Technical Physics

Year/Semester
2/3

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	Laboratory classes	Other (e.g. online)
45	0	0

Tutorials	Projects/seminars
30	0

Number of credit points

6,00

Coordinators

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Lecturers

Prerequisites

Knowledge from experimental physics and fundamentals of higher mathematics (linear algebra, differential and integral calculus, basics of probability theory). Ability to analytically solve physical problems based on rigorous reasoning using the necessary physical knowledge and appropriate mathematical methods. Understanding the need to expand one's competencies in the field of physics and willingness to collaborate within small teams.

Course objective

1. Introduce basic experimental facts and postulates of quantum physics, emphasizing its fundamental role in describing reality. 2. Present the basics of quantum mechanics formalism on selected examples in matrix and wave representations, familiarizing students with the appropriate mathematical apparatus and concepts, and developing their skills in qualitative and quantitative analysis of basic quantum phenomena. 3. Develop a constructive discussion attitude in teamwork.

Course-related learning outcomes

Knowledge:
1. Students know basic concepts and postulates of quantum mechanics related to the description of

quantum states, observables, and the evolution of a quantum state described by Schrödinger's equation, explaining the concepts and laws of quantum physics by referring to specific examples.
2. Students know basic experimental facts justifying quantum theory and understand the structure of quantum description and interpretation of fundamental physical phenomena, aware of the observation scale of quantum phenomena and the limitations of quantum theory, noting the differences between quantum and classical descriptions of the macroscopic world.
3. Students can identify the appropriate method to describe a quantum problem, either matrix or wave, suitable for the quantum phenomenon or the physical system structure. They know and select the appropriate mathematical apparatus for quantitative analysis of basic phenomena and quantum structures, pointing out fundamental implications of quantum theory, including those of technical application nature.

Skills:
1. Students can solve the eigenvalue problem of an observable represented by a finite-dimensional matrix and interpret the obtained results.
2. Students can present quantum states and observables in different bases, reasoning about the probability of outcomes, expected values, and uncertainties of measuring a physical quantity, proficiently using Dirac notation.
3. Students can determine the eigenfunctions and eigenvalues of energy for simple one-, two-, and three-dimensional systems, applying exact methods as well as selected approximate methods.
4. Students can solve simple problems related to particle scattering on a one-dimensional potential, determine probability current density, and calculate reflection and transmission coefficients.
5. Based on solving the eigenvalue problem of a physical system's energy, students can determine the time evolution of the considered quantum state without and with disturbance.

Social competences:
1. Students can independently or in cooperation with a team formulate hypotheses concerning solving a physical problem in the field of basic quantum physics.
2. Students understand the importance of systematic work to acquire directional competencies, acknowledging the key role of quantum physics.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Exercises:
- Form and components of assessment (percentage breakdown): ongoing assessments (100%);
- Assessment criteria / grade: 96% and above / 5.0; 86% - 95% / 4.5; 76% - 85% / 4; 66% - 75% / 3.5; 50% - 65.0% / 3; below 50% / 2.

Lecture:
- Form and components of assessment (percentage breakdown): ongoing short tests (40%), written exam - multiple choice and open-ended questions (40%), oral exam (20%);
- Assessment criteria / grade: 96% and above / 5.0; 86% - 95% / 4.5; 76% - 85% / 4; 66% - 75% / 3.5; 50% - 65.0% / 3; below 50% /

Programme content

none

Course topics

I. Formalism and problems of quantum physics in matrix approach.
1. Vectorial description of quantum states, probability amplitude and probability of quantum test (measurement). Quantum state superposition. Dirac notation.
2. Operators representing observables in matrix representation. Quantum mechanics and linear algebra - mathematical interlude. Issue of compatibility of physical quantities - uncertainty principle.
3. Evolution of quantum states in time. Resonance phenomenon.
4. Description of quantum states and construction of operators for systems composed of two subsystems - information about quantum entanglement.
II. Formalism and problems of quantum physics in wave approach.
1. Wave function and probability amplitude. Probability density. Momentum operator and position

operator. Positional vs momentum representation.
2. Schrödinger equation in positional representation. Time-independent Schrödinger equation. Stationary states.
3. Bound states of particles confined in one- and two-dimensional wells.
4. Scattering states. Particle scattering on potential barrier. Quantum tunneling phenomenon.
5. Harmonic oscillator.
6. Time evolution in Schrödinger and Heisenberg pictures.
III. Selected topics.
1. Rotational symmetry and angular momentum operator. Quantization of angular momentum - algebraic approach.
2. Quantization of orbital angular momentum. Stationary states of the hydrogen atom.
3. Approximate methods - stationary perturbation theory.
4. Elements of variational calculus.

Teaching methods

Lecture: multimedia presentations supplemented with examples provided on the board.
Exercises: individual and team problem-solving; guided and independent analysis of cases, e.g., concerning quantum circuits.

Bibliography

Basic:
1. Stanisław Kryszewski. Mechanika kwantowa, Wydawnictwo Uniwersytetu Gdańskiego 2020
2. Ramamurti Shankar, Mechanika kwantowa, Wydawnictwo Naukowe PWN 2014

Additional:
1. Richard P. Feynman., Robert B. Leighton , Matthew Sands Feynmana wykłady z fizyki Tom 3 Mechanika kwantowa, Wydawnictwo Naukowe PWN 2014
2. David H. McIntyre, Quantum mechanics: a paradigms approach, Pearson 2012
3. A. I. Lvowski, Quantum Physics. An Introduction Based on Photons. An Introduction Based on Photons. Springer 2018, pozycja dostępna w formie e-booka poprzez E-Zasoby Biblioteki Politechniki Poznańskiej
4. Mark Beck, Quantum mechanics : theory and experiment, Oxford University Press 2012

Breakdown of average student's workload

	Hours	ECTS
Total workload	150	6,00
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)	73	3,00