COURSE DESCRIPTION CARD - SYLLABUS

Course name
Quantum physics

Course

Field of study	Year/Semester
Technical Physics	2/3
Area of study (specialization)	Profile of study
	general academic
Level of study	Course offered in
First-cycle studies	polish
Form of study	Requirements
full-time	compulsory

Number of hours

Lecture	Laboratory classes	Other (e.g. online)
45		
Tutorials	Projects/seminars	
30		

Number of credit points

5

Lecturers

Responsible for the course/lecturer:
dr Gustaw Szawioła, doc. dydaktyczny

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Responsible for the course/lecturer:

Prerequisites

Knowledge of experimental physics, basics of higher mathematics (linear algebra, differential and integral calculus, basics of probability). The ability to analytically solve physical problems based on a strict argumentation based on the necessary physical knowledge and the use of adequate mathematical methods. Understanding the need to expand one's competences in the field of physics. Readiness to cooperate within small teams

Course objective

1. Familiarization with the basic experimental facts and postulates of quantum physics, with emphasizing its fundamental role in the description of reality.

2. Presentation of the basics of quantum mechanics formalism, based on selected examples, in the matrix and wave approach. To acquaint students with the appropriate mathematical and conceptual apparatus. Developing students' skills in qualitative and quantitative analysis of basic quantum phenomena.

3. Developing an attitude of constructive discussion in team work.

Course-related learning outcomes

Knowledge

1. The student knows the basic concepts and postulates of quantum engineering concerning the description of quantum states, observables and the evolution of the quantum state described by the Schrödinger equation. Concepts

and the laws of quantum physics, he explains by referring to specific examples.

2. The student knows the basic experimental facts justifying the quantum theory and understands the structure of quantum description and interpretation of basic physical phenomena. He knows the scale of observation of quantum phenomena and the limitations of quantum theory, indicates differences in the quantum description (mainly of the microworld) and the classical description of the macroscopic world.

3. Student identifies the correct way of describing a quantum problem, matrix or wave, adequate to the quantum phenomenon or the structure of the physical system. He knows and selects the appropriate mathematical apparatus for the quantitative analysis of basic quantum phenomena and structures. Indicates the basic implications of quantum theory, including the technical application.

Skills

1. The student solves his own problem of observables represented by finite dimensional matrices and interprets the obtained results.

2. The student presents quantum states and observables in various databases and is able to conclude about the probability of the result, the expected value and the uncertainty of the measurement of a physical quantity. He can use Dirac notation efficiently.

3. The student is able to determine the eigenfunctions and eigenvalues of energy of simple one-, two- and three-dimensional systems (included in the program content). Uses exact methods and selected approximate methods.

4. Student solves the simple problems of particle scattering on the one-dimensional potential; determines the probability current density and calculates the reflection and transmission coefficients.

5. The student on the basis of solving the problem of own energy of the physical system is able to determine the time evolution of the quantum state of the considered system without disturbance and with disturbance.

Social competences

1. The student is able to put forward hypotheses for solving a physical problem in the field of quantum physics by himself or in cooperation with a team.

2. Sudent understands the importance of systematic work in order to acquire directional competences, understanding the key role of quantum physics in this.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

2. Classes (learning outcomes: U01, U03, K01):

- form and components of the assessment (percentage): current tests (100%);

- evaluation criteria / evaluation: 96% - / 5.0; 86% - 95% / 4.5; 76% -85% / 4; 66-75% / 3.5; 50% -65.0% / 3; <50% / 2.

Lecture

- form and components of assessment (percentage): current short tests (40%), tests, written exam - selection test and open tasks (40%), oral exam (20%);

- evaluation criteria / evaluation: 96% - / 5.0; 86% - 95% / 4.5; 76% -85% / 4; 66-75% / 3.5; 50% -65.0% / 3; <50% / 2.

Programme content

I. Formalism and problems of quantum physics in the matrix approach.

1. Vector description of quantum states, probability amplitude and the passing probability of a quantum test (measurement). Superoposition of quantum states. Dirac notation.

2. Operators representing observables in a matrix representation. Quantum mechanics and linear algebra - mathematical interlude. The issue of co-measurability of physical quantities - the uncertainty principle.

3. Evolution of quantum states over time. The phenomenon of resonance.

4. Description of quantum states and construction of operators of systems composed of two subsystems - information about quantum entanglement.

II. Formalism and problems of quantum physics in the wave approach.

1. Wave function and probability amplitude. Probability density.

Momentum operator and position operator. Position and momentum representation.

2. Also Schrödinger in a positional representation. Time independent Schrödinger equation. Stationary states.

3. Bound states of a particle trapped in one- and two-dimensional wells.

4. Scattered states. Scattering particles on the potential barrier. The phenomenon of quantum tunneling.

5. Harmonic oscillator.

6. Evolution in time in the painting by Schrödinger and Heisenberg.

III. Selected Issues

1. Rotation symmetry and angular momentum operator. Angular quantization - algebraic approach.

2. Quantization of orbital angular momentum. Stationary states of the hydrogen atom.

3 Approximate methods - stationary perturbation calculus.

4. Elements of calculus of variations.

Teaching methods

Lecture: multimedia presentation, supplemented with examples given on the blackboard.

2. Exercises: individual and team problem solving; guided and self-directed case studies, e.g. on 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	137	5,0
Classes requiring direct contact with the teacher	77	3,0
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	60	2,0

[1] delete or add other activities as appropriate