Quantum mechanics foundations - course description

General information

Course name	Quantum mechanics foundations
Course ID	WFA-Erasmus-QMF
Faculty	Faculty of Physics and Astronomy
Field of study	WFiA - oferta ERASMUS
Education profile	-
Level of studies	Erasmus programme
Beginning semester	winter term 2023/2024

Course information

Semester	2
ECTS credits to win	6
Course type	obligatory
Teaching language	english
Author of syllabus	

Classes forms

The class form	Hours per semester (full-time)	Hours per week (full-time)	Hours per semester (part-time)	Hours per week (part-time)	Form of assignment
Lecture	30	2	-	-	Exam
Class	30	2	-	-	Credit with grade

Aim of the course

Introducing students to the historical development and basic concepts of quantum physics. In particular, to the interpretation of quantum phenomena and mathematical foundations of the description of these phenomena.

Prerequisites

Assumed background:

Physics: Wave Mechanics, Electromagnetism and Optics.

Mathematics: Vector algebra, vector calculus, series and limits, partial differentiation, multiple integrals, first- and second-order differential equations, Fourier series, matrix algebra, diagonalisation of matrices, eigenvectors and eigenvalues, coordinate transformations, special functions.

Scope

Topics covered in Lectures:

1. Wave nature of light.
2. Experiments demonstrating failing of the wave nature of light: spectrum of X radiation, photoelectric effect, Compton scattering, discrete atomic spectra, black body radiation.
3. Planck's quantum hypothesis.
4. The Bohr model of the hydrogen atom and its difficulties.
5. Duality of light and matter.
6. Quantum wave mechanics, meaning of wave function and its interpretation.
7. Superposition principle. Wave packets and the Heisenberg uncertainty relation.
8. Operator representation of physical quantities. Non-relativistic Schrodinger equation.
9. Applications of the Schrodinger's equation: potential wells, potential barrier, tunneling effect.
10. Linear operators and their algebra. Eigenvalues and eigenvectors. Dirac notation.
11. Matrix representation of wave function and operators. Diagonalization of matrices.
12. Quantum harmonic oscillator.
13. Quantum wave mechanics model of hydrogen atom.

Tutorials: Solving problems and exercises on topics covered in the lectures: For example, problems and exercises on elements of a theory of the linear operators, uncertainty principle, the square potential barrier, potential well, eigenvalues and eigenvectors of operators. Matrix representation and diagonalization of matrices.

Teaching methods

Teaching and Learning Methods:

Two hours per week are scheduled for lectures and two hours for tutorials.

Lectures will cover the formal course content.

Typed lecture notes and tutorial problems will be provided.

In the problem solving tutorials, students will be expected to discuss the tutorial problems provided.

Learning outcomes and methods of theirs verification

Outcome description	Outcome symbols	Methods of verification	The class form
The student understands the essence of quantum effects and processes, understands and can explain descriptions of physical phenomena and processes using mathematical language, can independently reproduce the claims and the rights and selected calculations. The student is able to create a theoretical model of the phenomenon and associate it with the results of measurements. The student can use the formalism of quantum mechanics to describe simple physical phenomena on the quantum level, is able to analyze and solve problems on the basis of physical knowledge and information from the available literature sources, databases and Internet resources. The student can independently acquire knowledge and develop their skills, using a variety of sources (in Polish and foreign) and new technologies. The student is aware of this knowledge and skills, and understands the need to know the possibilities of continuous further training in.		• a check work • a discussion • a final test	• Lecture • Class

Assignment conditions

Course examination:

Lectures: Final written exam. Correct answer to at least 2/3 of questions.

Tutorial: Activity during the tutorial hours demonstrating the ability of solving tutorial problems and a positive grade of the final test.

Before taking the final lecture examination the student needs to obtain passing grade of the tutorials.

The final grade: the arithmetic average of the tutorial and lecture examination grades.

Recommended reading

Main textbooks:

1. Z Ficek, *Quantum Physics for Beginners* (Pan Stanford, Singapore, 2016).

2. E. Merzbacher, *Quantum Mechanics*, (Wiley, New York, 1998).

3. D. J. Griffiths and D. F. Schroeter, Introduction to Quantum Mechanics (Cambridge University Press, 2021).

4. C. Cohen-Tannoudji, B. Diu, F. Laloe, Quantum Mechanics: Volume I: Basic Concepts, Tools, and Applications, Volume II: Angular Momentum, Spin, and Approximation Methods, (Wiley-VCH, 2019).

Further reading

Important reference books are:

1. R.A. Serway, C.J. Moses, and C.A. Moyer, *Modern Physics*, (Saunders, New York, 1989).

2. K. Krane, *Modern Physics*, (Wiley, New York, 1996).

Notes

Modified by dr hab. Sylwia Kondej, prof. UZ (last modification: 26-06-2023 15:53)