GHENT UNIVERSITY

Course Specifications

Valid in the academic year 2023-2024

Quantum Mechanics 1 (C002240)

Course size *(nominal values; actual values may depend on programme)*

Credits 6.0 **Study time 180 h**

Course offerings and teaching methods in academic year 2023-2024

A (semester 1)	Dutch	Gent	lecture
			seminar

Lecturers in academic year 2023-2024

Ryckebusch, Jan	WE05	lecturer-in-charge

Offered in the following programmes in 2023-2024	crdts	offering
Bachelor of Science in Mathematics	6	A
Bachelor of Science in Physics and Astronomy	6	A
Preparatory Course Master of Science in Physics and Astronomy	6	A

Teaching languages

Dutch

Keywords

Quantum mechanics, modern physics, particle-wave duality, Schrödinger equation, quantum entanglement

Position of the course

This course unit belongs to the *learning pathway "General physics" in the Bachelor program Physics and Astronomy.* Quantum mechanics gets introduced at an introductory level. The course illustrates that a number of crucial experiments that were carried out in the early 1900s prompted thorough revisions of existing physical theories in order to provide a proper description of the physics of subatomic phenomena. We start from the concept of the wave function. The time-dependent and time-independent Schrödinger equation are thoroughly studied as evolution equations in quantum mechanics. After dealing with the general formalism, attention is paid to the study of one-dimensional quantum systems. One of the major goals of the course is to establish the importance of quantum mechanics for the description of many systems.

Contents

- Introduction to quantum mechanics (black-body radiaton, particle properties of radiation, energy spectrum of atoms and molecules, photoelectric effect, Compton effect, Stern-Gerlach experiment, energy quantisation, directional quantisation, spin)
- Introduction to the microscopic structure of atoms and atomic nuclei. Quantum mechanics and the subatomic world.
- Properties of matter (Bohr's atomic model, de Broglie wave nature of matter, double-slit experiment)
- The concept of wave function as a probability amplitude (particle-wave duality, free particle, wave packets, momentum wave function and Fourier transformations, position-momentum uncertainty in quantum mechanics)
- The Schrödinger equation (connection with classical wave theory, time-dependent Schrödinger equation, continuity equation, current conservation, expectation value, Ehrenfest theorem, time-independent Schrödinger equation, energy quantisation, eigenvalue problems: energy spectrum and wave functions, superposition)
- One-dimensional systems (free particle, potential step, various potential well problems, quantum tunneling, harmonic oscillator)
- The formalism and axioms of quantum mechanics (Dirac bra-ket vectors, measurement process in quantum mechanics, representations in quantum mechanics, occupation number

representation for the harmonic oscillator, dynamical variables and operators, matrix representation of quantum mechanics)

Initial competences

Prerequisites: basics of physics (mechanics, waves and optics, electricity and magnetism) and the basics of mathematics (linear algebra, functions, calculus, vector analysis).

Final competences

1 Possess the basic knowledge of quantum mechanics indispensable for studying subjects like condensed-matter physics, nuclear physics, atomic and molecular physics, elementary particle physics.
2 To possess the required background knowledge to study the important branches of theoretical physics like relativity, advanced quantum mechanics, statistical physics, and field theory.
3 The student has a sound knowledge of the mathematical aspects of quantum mechanics, including probability distributions, probability currents, second-order partial differential equations, Hilbert spaces, constrained eigenvalue problems.
4 Possess the skills and knowledge to compute the properties of one-dimensional quantum systems.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Seminar, Lecture

Extra information on the teaching methods

Lectures present the theoretical concepts. Tutorials aim at providing a deeper insight into the concepts of the course. The tutorials train the students in problem solving.

Learning materials and price

All course materials are available free of charge through the electronic learning environment. Mandatory text book is "Quantum Mechanics", B.H.Bransden and C.J. Joachain, (Second Edition, Prentice Hall, 2002), (about 50,00 €).

References

1 *"Quantum Mechanics: A Paradigms Approach", David H. McIntyre (Pearson Education, San Francisco, 2012)*
2 *"Quantum Mechanics: an accessible introuction", Robert Scherrer (Pearson Education, San Francisco, 2005)*

Course content-related study coaching

The possibility is provided for students to contact the lecturer(s) after the lecture hours. Appointments for small groups of students can be arranged in order to supply Additional course information.

Assessment moments

end-of-term assessment

Examination methods in case of periodic assessment during the first examination period

Written assessment with open-ended questions

Examination methods in case of periodic assessment during the second examination period

Written assessment with open-ended questions

Examination methods in case of permanent assessment

Possibilities of retake in case of permanent assessment

not applicable

Extra information on the examination methods

- The written exam consists of two parts: an open-book part and a closed-book part. The open-book part has a number of problems that the student has to solve.

Calculation of the examination mark

- 40% for the open-book part of the written exam

- 60% for the closed-book part of the written exam