Faculty of Science

FYSB22, Physics: Basic Quantum Mechanics, 7.5 credits

Fysik: Grundläggande kvantmekanik, 7,5 högskolepoäng

First Cycle / Grundnivå

Details of approval

The syllabus was approved by Study programmes board, Faculty of Science on 2020-07-02 and was last revised on 2024-11-27 by The Education Board of Faculty of Science. The revised syllabus comes into effect 2024-11-27 and is valid from the autumn semester 2025.

General information

The course is a compulsory course at first cycle level for a degree of Bachelor of Science in Physics and is a compulsory course for a degree of Master of Science in Computational Science with specialisation in Physics.

Language of instruction: English

Main field of study	*Specialisation*
Physics	G2F, First cycle, has at least 60 credits in first-cycle course/s as entry requirements

Learning outcomes

The general aim of the course is that students after completed course should have acquired knowledge and skills in the basic quantum mechanics that are needed for continued studies of quantum physics. The course is based on the knowledge described in the course syllabi for the courses: FYSA12, FYSA13, FYSA14, MATA21, MATA22, NUMA01, MATB21 and good knowledge of their all in all contents facilitate for the student to carry out the course. Bachelor students are expected to take the course FYSB21 parallel with this course.

Intended learning outcomes in the programme syllabus refer to the programme syllabus of the Degree of Bachelor in physics at Lund University which corresponds to targets for general qualification in the Higher Education Ordinance in turn.

1 - 4 is interim target against intended learning outcome 1 the programme syllabus.

5 - 9, 11 and 12 is interim target against intended learning outcome 3 in the programme syllabus.

1 and 10 is interim target against intended learning outcome 4 in the programme syllabus.

10 and 11 is interim target against intended learning outcome 5 in the programme syllabus.

13 and 14 is interim target against intended learning outcome 6 in the programme syllabus.

15 is interim target against intended learning outcome 7 in the programme syllabus.

15 and 16 is interim target against intended learning outcome 8 in the programme syllabus.

Knowledge and understanding

On completion of the course, the students shall be able to:

1. describe the basic properties of quantum particles as well as explain key concepts such as wave-particle duality, wave function and superposition
2. formulate, and qualitatively justify the Schrödinger equation
3. explain and provide examples of how operators in quantum mechanics are used to represent observable physical quantities
4. formulate expressions for a measurement on a quantum particle and explain central concepts as probability, outcome, expectation value and uncertainty.

Competence and skills

On completion of the course, the students shall be able to:

5. solve the Schrödinger equation for an infinite potential well in one dimension as well as describe the main features of the solution and its properties for a finite well
6. calculate the probability and describe the qualitative properties of transmission through simple potential structures in one dimension
7. derive basic operator relations and perform simple calculations using operators
8. carry out simple approximate calculations of energies based on pertubation theory and variational method
9. formulate the Schrödinger equation for the harmonic oscillator in one dimension in terms of ladder operators, as well as calculate and describe the key properties of wave functions and eigen energies
10. in a small group, carry out experimental laboratory sessions in the subject and present the work in a written laboratory report
11. use numerical methods to solve quantum mechanical problems
12. based on a probability distribution decide different expectation values of individual statistical variables and the sum of several independent variables.

Judgement and approach

On completion of the course, the students shall be able to:

13. assess in which situations a quantum mechanical method is required
14. evaluate the importance of statistical uncertainties in quantum mechanics
15. explain and give examples of the role of quantum mechanics in the societal progress
16. based on the course learning outcomes and their own goals, reflect on their progress with regard to knowledge and skills.

Course content

The course covers basic quantum mechanics. Specific topics covered:

- wave-particle duality, superposition and wave function
- the Schrödinger equation
- bound states in one dimension
- scattering in one-dimensional potentials
- operators, observables and operator relations
- measurements, expected values and uncertainty
- harmonic oscillator
- approximate methods for the calculation of energies

Course design

The teaching consists of lectures and calculation exercises and laboratory and numerical projects. Participation in introduction meeting, introduction to the project, laboratory and numerical projects and self-reflection is compulsory. In addition, optional written assignments give the possibility to bonus point for the written examination.

Assessment

The assessment is based on:

- compulsory laboratory and numerical projects and reports during the course, which corresponds to 2 credits and mainly assess intended learning outcomes 10 and 11
- a written examination at the end of the course, that corresponds to 5.5 credits and assess mainly intended learning outcomes 1-9, 11-15.
- compulsory self-reflection mainly assesses intended learning outcome 16.

Students who do not pass an assessment will be offered another opportunity for assessment soon thereafter.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

Grades

Grading scale includes the grades: Fail, Pass, Pass with distinction
For a Pass grade on the whole course, the student must have Pass grades on the reports and the written examination, as well as have participated in all compulsory components:

- introduction meeting
- introduction to the project
- laboratory and numerical projects

- self-reflection on learning.

Calculation of grade

- Self-reflection and laboratory and numerical projects only give grade Fail and Pass and not are used to calculate a final grade.
- The written examination gives a grade based on the proportion of completed credits. The minimum required for a Pass is normally 50% while the minimum for a Pass with Distinction is 80%.
- When all components are graded Pass or Pass with distinction, the grade for the whole course is decided by the written examination result.

Entry requirements

Entry to the course requires general entry requirements and 30 credits in mathematics (maximum one of the courses incomplete, but at least followed) including courses equivalent to:

- MATA21 Analysis in One Variable, 15 credits,
- MATA22 Linear Algebra 1, 7.5 credits, and
- NUMA01 Computational Programming with Python, 7.5 credits,

and an additional 15 credits in mathematics (at least taken) including courses equivalent to:

- MATB21 Analysis in Several Variables 1, 7.5 credits, and
- MATB22 Linear Algebra 2, 7.5 credits.

and either 30 credits in physics (maximum one of the courses incomplete, but at least followed) including courses equivalent to:

- FYSA22 Introduction to University Physics, with Mechanics, 7.5 credits
- FYSA23 Introduction to University Physics, with Electricity, 7.5 credits
- FYSA13 Introduction to University Physics, with Optics, Waves and Quantum Physics, 7.5 credits and
- FYSA14 Introduction to University Physics, with Thermodynamics, Climate and Experimental Methodology, 7.5 credits.

or an additional 30 credits in mathematics (maximum one of the courses incomplete, but at least followed) including courses equivalent to:

- MATB23 Analysis in Several Variables 2, 7.5 credits and
- MATB24 Linear Analysis, 7.5 credits.

Students who have obtained the equivalent knowledge by other means may also be admitted to the course.

Further information

The course is part of the Bachelor's programme in physics, theoretical physics, astrophysics of the medical physics program, or of the Master’s programme in computational science, physics. The teaching is based on the assumption that the student follows the program and has assimilated the knowledge in the previous courses, and takes other program courses in parallel. For those who have acquired equivalent knowledge in other ways, the course can be taken as a stand-alone course.

The course may not be included in a degree together with FYSB11 Physics: Basic Quantum Mechanics, 7.5 credits.

The course is offered at the Department of Physics, Lund University.