Faculty of Science

FYST89, Physics: Advanced Quantum Mechanics, 7.5 credits

Fysik: Avancerad kvantmekanik, 7,5 högskolepoäng

Second Cycle / Avancerad nivå

Details of approval

The syllabus was approved by The Education Board of Faculty of Science on 2025-06-06. The syllabus comes into effect 2025-06-06 and is valid from the spring semester 2026.

General information

The course is an elective course for second cycle studies for a scientific candidate - or Master's degree (120 credits) in physics.

Language of instruction: English

Main field of study	*Specialisation*
Physics	A1N, Second cycle, has only first-cycle course/s as entry requirements
Computational Science with specialization in Physics	A1N, Second cycle, has only first-cycle course/s as entry requirements

Learning outcomes

The overall goal of the course is for the student to acquire in-depth knowledge of quantum mechanics with a focus on advanced methods for describing angular momentum, scattering problems and identical particles. The role of symmetry is particularly emphasised.

Knowledge and understanding

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

- explain the Feynman path integral formulation
- describe the relationship between angular momentum and the rotational group
- explain the quantum mechanical description of relativistic effects.

Competence and skills

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

- use different representations of quantum dynamics (Heisenberg, Schrödinger, interaction)
- discuss the relationship between quantum mechanical properties and symmetries
- independently solve quantum mechanical scattering problems
- apply the occupation number formalism.

Judgement and approach

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

- reflect on interpretations of quantum mechanics.

Course content

Description of the subject-related contents of the course:

- Quantum mechanical time evolution: Schrödinger and Heisenberg representation, propagator, potentials and gauge transformations.
- Mixed state and density operator
- Angular momentum: commutator relations and Euler rotations, representations of the rotation operator, rotation matrices, addition of angular momentum, Bell's inequality, tensor operators, Wigner–Eckart theorem.
- Symmetries: parity, periodic potentials, time reflection.
- Many-particle theory: identical particles, bosons and fermions, field operators.
- Scattering theory: The Lippman–Schwinger equation, the Born approximationen, the optical theorem, partial waves, resonance scattering, time-dependent formalism.
- The Dirac equation.

Course design

The teaching consists of lectures and seminars.

Assessment

Examination takes place in the form of a written examination at the end of the course.

Students who do not pass a regular assessment will be offered another opportunity for assessement 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
To pass the entire course, a passed examination is required. The final grade is decided by the written examination.

Entry requirements

Admission to the course requires at least 75 credits in physics and 45 credits in mathematics, or at least 30 credits in physics and 90 credits in mathematics, or a bachelor's degree in physics, physical chemistry or equivalent. General entry requirements and English 6/B.

Further information

Assumed prior knowledge: The teaching in the course is based on the student having acquired knowledge corresponding to FYSN27, Quantum Mechanics, 7.5 credits.

This course replaces FYST37, Physics: Quantum Mechanics, 7.5 credits and cannot be included in a degree together with this course.

The course is in full coordinated with FMFN10, Quantum Mechanics, Advanced Course 2, 7.5 credits which is a course given at Lund Institute of Technology, LTH. The examination of the course is scheduled in accordance with the LTH exam schedule.

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