Reg No: FYGB07/20251

Faculty of Health, Science and Technology
Physics

Syllabus

Quantum Physics I

Course Code:	FYGB07
Course Title:	Quantum Physics I *Kvantfysik I*
Credits:	7.5
Degree Level:	Undergraduate level
Progressive Specialisation:	First cycle, has at least 60 credits in first-cycle course/s as entry requirements (G2F)

Major Field of Study:
FYA (Physics)
TKA (Engineering Physics)

Course Approval
The syllabus was approved by the Faculty of Health, Science and Technology 2024-09-12, and is valid from the Spring semester 2025 at Karlstad University.

Prerequisites
Completed courses in Physics, 22.5 ECTS credits, and Mathematics, 22.5 ECTS credits, plus registered for Linear algebra, 7.5 ECTS credits, Calculus and geometry, 7.5 ECTS credits, and Calculus in several variables, 7.5 ECTS credits, or equivalent

Learning Outcomes
The aim of the course is for students to deepen their understanding of quantum mechanical phenomena and models as well as develop their ability to analyse quantum mechanical systems of single particles and the hydrogen atom mathematically.

Upon completion of the course, students should be able to:
- give an account of some of the most important historical experiments that showed the inadequacy of classical physics for describing physical phenomena, such as the spectral

distribution of blackbody radiation, the photoelectric effect, the Compton effect, and the line spectra of atoms,
- give an account of the concepts, postulates, and formalism of quantum mechanics, and apply these when solving problems,
- give an account of both the similarities and the differences between classical mechanics and quantum mechanics,
- solve the Schrödinger equation for one-dimensional model potentials and give an account of some of its applications,
- give an account of the different types of angular momentum in quantum mechanics and treat their most important representations mathematically, and
- give an account of the solution of the Schrödinger equation in two and three dimensions through the separation method, and apply it to the harmonic oscillator and the hydrogen atom,

Content
Instruction is in the form of lectures and calculation exercises.

The course covers the following:
- The emergence and structure of quantum theory: the interpretation and properties of the wave function, the superposition principle, wave packets, Heisenberg's uncertainty relation, the time-dependent Schrödinger equation, free particles, probability current and probability conservation, expectation values, the correspondence principle, operators, commutators, Hermitean operators, the time-independent Schrödinger equation, and stationary states.
- Applications in one dimension: rectangular potentials, the harmonic oscillator, and the tunneling phenomenon.
- The postulates and formalism of quantum mechanics: Dirac's bra-ket notation, Hermite conjugation, eigenfunctions as orthonormal bases, wave function collapse, compatible observables, the time evolution of expectation values, the general uncertainty principle.
- Angular momentum: eigenfunctions for angular momentum operators, the Legendre polynomials and spherical harmonics, the rotation energy of molecules, general angular momentum and spin, spin in matrix bases, and addition of angular momenta, step operators.
- Solution of the Schrödinger equation in three dimensions: separation ansätze, three-dimensional rectangular and harmonic potentials, central potential, and the hydrogen atom.

Reading List
See separate document.

Examination
Assessment is based on a written exam and hand-in assignments.

If students have a decision from Karlstad University entitling them to Targeted Study Support due to a documented disability, the examiner has the right to give such students an adapted examination or to examine them in a different manner.

Grades
One of the grades Distinction (VG), Pass (G), or Fail (U) is awarded in the examination of the course. For students in Engineering, one of the grades 5 (Pass with Distinction), 4 (Pass with Some Distinction), 3 (Pass), or U (Fail) is awarded in the examination of the course.

Quality Assurance
Follow-up relating to learning conditions and goal-fulfilment takes place both during and upon completion of the course in order to ensure continuous improvement. Course evaluation is partly based on student views and experiences obtained in accordance with

current regulations and partly on other data and documentation. Students will be informed of the result of the evaluation and of any measures to be taken.

Course Certificate
A course certificate will be provided upon request.

Additional information
The local regulations for studies at the Bachelor and Master levels at Karlstad University stipulate the obligations and rights of students and staff.