



Faculty of Health, Science and Technology
Physics

Syllabus

Quantum physics for doctoral students

Course code:	2FYS016
Course Title:	Quantum physics for doctoral students Kvantfysik för doktorander
Subject:	Physics
Credits:	7,5 ECTS
Degree Level:	Doctoral

Course approval

The syllabus was approved by the Faculty of Health, Science and Technology, 31, May, 2023 and is valid from the autumn semester 2023 at Karlstad University.

Language of instruction

Teaching is mainly in Swedish and English, depending on the lecturer's natural language. If there are participants unfamiliar with Swedish English is used as the course language.

Prerequisites and selection

Admitted to research education in Physics or other discipline.

Physics 60 ECTS, including the course Quantum Physics I, or equivalent.

The course is primarily for research education students admitted at Karlstad University, and secondarily for research education students admitted at other universities.

Learning outcomes

After completed course the research education student should know:

- to give an account of the most important approximation methods for both time-independent and time-dependent problems in quantum mechanics and their respective areas of validity, as well as demonstrate proficiency in their application,
- to give an account of the dipole approximation and dipole active transitions,
- to give an account of quantum mechanical descriptions of several- and many-particle

systems and demonstrate proficiency in the computation of multi-electron atoms and simple molecules,

- to apply quantum mechanics concepts to describe atomic and molecular orbitals and chemical bonds.
- to give an account of and analyze the interaction of matter with electromagnetic radiation and with electric and magnetic fields,
- to give an account of the central concepts of statistical quantum mechanics and be able to perform basic quantum mechanical computations with density operators,
- to reflect on and discuss some central problems concerning the interpretation of quantum mechanics,
- to give an account of the molecular structure and vibrational and electronic spectra,
- to conduct spectroscopic experiments, analyze and interpret the obtained spectra,
- to demonstrate the ability to interpret scientific texts, and
- to give an account of the connection between quantum physics in their research specialization and the course content.

Course content

The course is taught as individual study followed by discussions and an in-depth assignment close to the student's research specialization.

The following topics will be covered in the course:

- the harmonic oscillator and applications, step operators;
- several- and many-particle systems, especially fermionic systems;
- time-independent and time-dependent perturbation theory and selection rules;
- the interaction of quantum systems with electromagnetic radiation as well as with external electric and magnetic fields;
- atomic and molecular orbitals, chemical bonds;
- quantum statistics;
- applications of quantum physics, and the interpretation of quantum physics;
- molecular structure and spectra;
- hands-on laboratory assignment(s) on spectroscopy of atoms, molecules, and solid materials.

Reading list

See separate document.

Examination

Assessment is based on written and oral presentation of an individual in-depth assignment, an oral examination, and laboratory reports.

Grades

One of the grades Fail (U) or Pass (G) is awarded in the examination of the course.

Quality assurance

A written evaluation is carried out at the conclusion of the course. The result of the evaluation is collated in accordance with *The Higher Education Ordinance*, Chapter 1, § 14.

Course Certificate

Course certificate is issued on request.

Goal matrix

Goals that, after completing the course, are fulfilled for the doctoral or licentiate degree are marked with an X.

	Doctoral			Licentiate	
	Knowledge and understanding			Knowledge and understanding	
1a	- demonstrate broad knowledge and systematic understanding of the research field and	X		1a demonstrate knowledge and understanding in the field of research including	X
1b	advanced and up-to-date specialised knowledge in a limited area of this field, and	X		1b current specialist knowledge in a limited area of this field as well as	X
1c	familiarity with research methodology in general and the methods of the specific field of research in particular.			1c specialised knowledge of research methodology in general and the methods of the specific field of research in particular	
	Competence and skills			Competence and skills	
2a	- demonstrate capacity for scholarly analysis and synthesis as well as	X		2a demonstrate the ability to identify and formulate issues with scholarly precision critically, autonomously and creatively and to	X
2b	to review and assess new and complex phenomena, issues and situations autonomously and critically			2b plan and use appropriate methods to undertake a limited piece of research and other qualified tasks within predetermined time frames in order to contribute to the formation of knowledge	
3a	- demonstrate the ability to identify and formulate issues with scholarly precision critically, autonomously and creatively, and to			2c as well as to evaluate this work	
3b	plan and use appropriate methods to undertake research and other qualified tasks within predetermined time frames and to review and evaluate such work			3a demonstrate the ability in both national and international contexts to present and discuss research and research findings in speech and writing and in dialogue with the academic community and	
4	- demonstrate through a dissertation the ability to make a significant contribution to the formation of knowledge through his or her own research			3b society in general	

5a	- demonstrate the ability in both national and international contexts to present and discuss research and research findings authoritatively in speech and writing and in dialogue with the academic community and		4	demonstrate the skills required to participate autonomously in research and development work and to work autonomously in some other qualified capacity.	X
5b	society in general				
6	- demonstrate the ability to identify the need for further knowledge and	X			
7	- demonstrate the capacity to contribute to social development and support the learning of others both through research and education and in some other qualified professional capacity.				
Judgement and approach				Judgement and approach	
8a	- demonstrate intellectual autonomy and disciplinary rectitude as well as		5	demonstrate the ability to make assessments of ethical aspects of his or her own research	
8b	the ability to make assessments of research ethics, and		6	demonstrate insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used	
9	- demonstrate specialised insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used.		7	demonstrate the ability to identify the personal need for further knowledge and take responsibility for his or her ongoing learning.	X