



Faculty of Health, Science and Technology
Physics

Syllabus

Quantum field theory

Course Code:	FYAD12
Course Title:	Quantum field theory <i>Kvantfältteori</i>
Credits:	7.5
Degree Level:	Master's level
Progressive Specialisation:	Second cycle, has second-cycle course/s as entry requirements (A1F)

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

Course Approval

The syllabus was approved by the Faculty of Health, Science and Technology 2023-09-04, and is valid from the Spring semester 2024 at Karlstad University.

Prerequisites

90 ECTS credits in Physics, including Quantum Physics I, 7.5 ECTS credits and Analytic Mechanics, 7.5 ECTS credits, plus 45 ECTS credits in Mathematics, including Linear Algebra, 7.5 ECTS credits, Calculus and Geometry, 7.5 ECTS credits, and Calculus in Several Variables, 7.5 ECTS credits, and registered for Symmetry - Mathematical Structures and Applications, 7.5 ECTS credits, plus upper secondary level English 6, or equivalent

Learning Outcomes

The aim of the course is for students to acquire both basic and in-depth knowledge of structures and methods used in quantum field theory and applications, especially in particle physics but also in other areas.

Upon completion of the course, students should be able to:

- give an account of the essential ingredients of canonical quantisation and path integral quantisation,
- give an account of the connection between the various elements of the computation of scattering cross sections: interacting fields, perturbation theory, Feynman diagrams, and scattering matrix,
- explain why and how IR and UV divergences arise in quantum field theories, as well as how divergences are treated in the renormalisation programme,
- perform calculations of basic scattering processes in quantum electrodynamics at tree level as well as compute simple one-loop diagrams,
- give an account of the terms space-time symmetry, internal symmetry, gauge symmetry, and gauge fixing, and give examples of various types of symmetries in particle physics, and
- give an account of the particles and interactions which enter into the standard model of particle physics, and indicate which terms in the Lagrange density of the standard model correspond to the individual interactions.

Content

The course covers the following:

- Motivation and foundations; fields and particles
- The basics of representation theory: spinor representations, spin-statistics
- Renormalisation and gauge invariance: examples from quantum electrodynamics, effective field theory
- Symmetry and broken symmetry: effective potential, non-abelian gauge theory, the Anderson-Higgs mechanism
- Standard model: quantisation of Yang-Mills theory, lattice gauge theory
- Topological quantum field theory: Chern-Simons theory

A group project based on these topics is included.

Reading List

See separate document.

Examination

Assessment is based on oral and written presentations of a group project, individual hand-in assignments, and an individual oral exam.

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 Engineering students, 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.