



The Faculty of Health, Science and

Curriculum for doctoral studies in Physics

(Studieplan för utbildning på forskarnivå i fysik)

Curriculum Approval

The syllabus was approved by the Faculty Board of Health, Science and Technology on 15 December 2022 and valid from this date.

General stipulations for third-cycle education are provided in the Higher Education Act and in the Higher Education Ordinance. Doctoral programmes at Karlstad University are offered to the extent allowed by available resources.

1. General Information

The science of physics studies describes the fundamental levels of nature, from the smallest components of matter to the entire universe. For instance, physics describes the laws that govern the properties and structures of matter and their applications. Physics research is highly international and pursued at most universities in the world.

The discipline is broad with many areas of specialisation.

Traditionally, there is a main division between experimental and theoretical research. Experimental physics often relies on very advanced experimental equipment in research, while theoretical physics often relies on powerful theoretical tools such as advanced mathematical and numerical methods. Physics education centres on teaching and learning in physics.

The doctoral programme in physics at Karlstad University offers three different specialisations:

- materials physics
- theoretical physics
- physics education

The doctoral programme in physics includes collaboration with other universities both within and outside of Sweden. In some cases, students pursue doctoral studies within the framework of the national graduate schools.

In compliance with the Karlstad University gender equality policy, the gender perspective should be included in third-cycle courses and programmes. Doctoral students should also gain insight into multidisciplinary approaches and experience from interactions across traditional disciplinary borders.

2. Aims and Objectives

The general objectives of licentiate or doctoral studies in terms of knowledge and understanding, competence and skills, and judgement and approach are specified as follows in the System of Qualifications (Higher Education Ordinance, Annex 2):

Degree of Licentiate

Knowledge and understanding

*For a **Degree of Licentiate** the third-cycle student shall demonstrate knowledge and understanding in the field of research including current specialist knowledge in a limited area of this field as well as specialised knowledge of research methodology in general and the methods of the specific field of research in particular.*

Competence and skills

For a **Degree of Licentiate** the third-cycle student shall

- demonstrate the ability to identify and formulate issues with scholarly precision critically, autonomously and creatively, and to 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 as well as to evaluate this work
- 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 society in general, and
- demonstrate the skills required to participate autonomously in research and development work and to work autonomously in some other qualified capacity.

Judgement and approach

For a **Degree of Licentiate** the third-cycle student shall

- demonstrate the ability to make assessments of ethical aspects of his or her own research,
- demonstrate insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used, and
- demonstrate the ability to identify the personal need for further knowledge and take responsibility for his or her ongoing learning.

Degree of Doctor

Knowledge and understanding

For the **Degree of Doctor** the third-cycle student shall

- demonstrate broad knowledge and systematic understanding of the research field as well as advanced

and up-to-date specialised knowledge in a limited area of this field, and

- demonstrate familiarity with research methodology in general and the methods of the specific field of research in particular.

Competence and skills

For the **Degree of Doctor** the third-cycle student shall

- demonstrate the capacity for scholarly analysis and synthesis as well as to review and assess new and complex phenomena, issues and situations autonomously and critically,
- demonstrate the ability to identify and formulate issues with scholarly precision critically, autonomously and creatively, and to plan and use appropriate methods to undertake research and other qualified tasks within predetermined time frames and to review and evaluate such work,
- demonstrate through a dissertation the ability to make a significant contribution to the formation of knowledge through his or her own research
- 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 society in general
- demonstrate the ability to identify the need for further knowledge and

- *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

*For the **Degree of Doctor** the third-cycle student shall*

- *demonstrate intellectual autonomy and disciplinary rectitude as well as the ability to make assessments of research ethics, and*
- *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.*

Subject-Specific Objectives

There are no subject-specific objectives.

3. Admission Requirements

The requirements for admission to third-cycle courses and study programmes are that the applicant meets the general and specific entry requirements, and is considered in other respects to have the ability required to benefit from the course or study programme.

3.1 General Eligibility

A person who has earned a Master's degree of at least 240 ECTS credits of which at least 60 ECTS cr are studies at Master's level, or who in some other way in the country or abroad has acquired largely equivalent knowledge has general eligibility for admission. If there are special reasons for doing so, the faculty board may grant an individual applicant exemption from the general eligibility (Higher Education Ordinance, Ch.7, Sec.39).

3.2 Special Eligibility

A person who has a Master's degree with a Major in physics with a specialisation in a relevant area has special eligibility for admission to doctoral studies in physics. Also eligible is a person who has a Master's degree with a different Major, of which at least 60 ECTS credits are in an area relevant to doctoral studies in physics, such as a Master of Science degree in Engineering Physics or in Teacher Education with equivalent specialisation in physics.

4. Admission Procedures

Applications for admission to doctoral studies are processed in accordance with the procedures prescribed by Karlstad University's admission regulations.

5. Selection

Candidates will be selected based on their assessed capacity to successfully complete a programme at the doctoral level.

The selection will be based on the applicant's previous study results and the quality of independent written work of a scholarly and investigatory nature included in the course or programme, in relation to the intended specialisation of the third-cycle education. The selection also considers the applicant's ability to attend and participate in the subject's research environment.

6. Content and Outline

The doctoral programme can lead to a doctoral or licentiate degree. The licentiate degree requires two years of study, the equivalent of 120 credits. The doctoral degree requires four years of study, the equivalent of 240 credits. The studies include course work as well as an independent project (licentiate or doctoral thesis).

Course work includes both courses and other activities that entitle the doctoral student to credits. To earn a licentiate degree, the candidate is required to complete 30 credits of course work and a thesis comprising 90 credits. To earn a doctoral degree, the candidate is required to complete 60 credits of course work and a thesis comprising 180 credits.

6.1 Courses

Courses offered at Karlstad University and at other universities in Sweden or abroad in the discipline and other related subjects can be included in the programme. The number of credits is decided by the examiner, in consultation with the student and the supervisor. Course selection should be made on the basis of the student's theoretical and methodological needs and is made in consultation with the examiner and supervisor.

Generic courses:

A research ethics course of at least 3 ECTS credits must be included in the doctoral programme in physics:

- Research Ethics for Doctoral Students, 3 ECTS credits, or an equivalent course.

In addition to the research ethics course, generic courses of at least 9 ECTS credits must be included in the doctoral programme. Elective generic courses at the doctoral level:

- Philosophy and Theory of Science for Doctoral Students, at least 3 ECTS credits
- Communicating Science, at least 3 ECTS credits
- Information Retrieval, at least 3 ECTS credits
- Writing in Science and Technology, at least 3 ECTS credits

or equivalent courses.

Third-cycle students who intend to participate in teaching at the first-cycle level are required to complete relevant courses in higher education pedagogy.

Subject-Specific Courses:

Subject-specific courses are selected in consultation with the student, supervisor and examiner. The selected courses are listed in the individual study plan.

Specialisation in theoretical and materials physics

For a Degree of Licentiate in physics with a specialisation in theoretical physics and materials physics, courses of at least 15 ECTS credits in physics are required.

For a Degree of Doctor in physics with a specialisation in theoretical physics and materials physics, courses of at least 30 ECTS credits in physics are required, of which no more than 15 may be at Master's level. At least 15 ECTS credits should be elective doctoral-level courses in physics for the chosen specialisation.

Elective doctoral-level courses for the specialisation in materials physics are:

- Quantum Physics for PhD Students, 7.5 ECTS credits
- Solid State Theory, 7.5 ECTS credits
- Surface Physics, 7.5 ECTS credits

Elective doctoral-level courses for the specialisation of theoretical physics are:

- Quantum Field Theory, 7.5 ECTS credits
- Quantum Field Theory in Condensed Matter Physics, 7.5 ECTS credits

Equivalence assessment may be made.

Specialisation in physics education

For a Degree of Licentiate in physics with a specialisation in physics education, courses of at least 7.5 ECTS credits in subject-specific education and 7.5 ECTS credits in physics are required.

For a Degree of Doctor in physics with a specialisation in physics education, the doctoral-level course Science, Mathematics and Technology Education Research, 15 ECTS credits, or equivalent, and at least 15 ECTS credits in physics are required, of which no more than 7.5 may be at Master's level. At least 7.5 ECTS credits should be an elective doctoral-level course in physics.

Equivalence assessment may be made.

Other Mandatory Components

- Every doctoral student is required to attend at least one international academic conference. The student is also required to present their own research findings at such a conference and is awarded 1 ECTS credit per conference up to 3 credits.
- The student will attend academic seminars and colloquiums. The student will at least twice present their own research findings at a seminar (once for a Licentiate) and is awarded 1 ECTS credits per presentation up to 2 credits.

6.2 Licentiate and Doctoral Theses

Third-cycle students are required to write a thesis for a doctoral or a licentiate degree, either as a monograph or as a compilation thesis. The licentiate thesis is to be defended at a licentiate seminar and the doctoral thesis at a public examination. Further information is available in Karlstad University's policy document: Regulations for Third-Cycle Studies. The thesis topic for either degree is chosen in consultation with the supervisor and examiner.

In physics, the doctoral thesis is normally a compilation thesis of 4-5 papers written in English. The papers included must be of such academic quality that

they meet the requirements for publication in high-quality international journals with a peer review system.
The student's own contribution must be clearly distinguishable in the thesis.

6.3 Supervision

Doctoral students are entitled to a supervisor in accordance with the current admission regulations for third cycle education at Karlstad University.

6.4 Individual Study Plan

At the start of the studies the doctoral student shall, in consultation with their supervisors, draw up an individual study plan. The plan should include a realistic time plan for coursework, thesis work and supervision. The plan should also include an introduction to the proposed research field and relevant ethical considerations.

The individual study plan shall use the form or system approved by the university.

The individual study plan is subject to continual review (at least once a year). If this results in changes in terms of timetable or project plan, the individual study plan must be revised.

Goal attainment of the research programme shall be reviewed on two occasions during the course of the programme. After one year, an individual goal matrix shall be formulated and added to the research student's individual study plan as an appendix.

One year before the planned date for the licentiate degree and two years before the planned date for the doctoral degree, the outcome of the individual goal matrix is evaluated in connection with the revision of the individual study plan. If the evaluation shows that the goal attainment is not satisfactory, the plan for the continuing studies will be revised to ensure that the national goals are met by the time of examination. A revised goal matrix is attached to the revised individual study plan.

6.5 Examination

Doctoral students are examined in accordance with the requirements of each individual course syllabus. Licentiate and doctoral theses are assessed in accordance with the Higher Education Ordinance (Chap. 6, Sec. 32-35) and Karlstad University's current regulations.