Faculty of Technology and Science

Curriculum for Doctoral Studies in Physics at Karlstad University

Approved by the Faculty Board (Reg.No F1/98). Revised by the Faculty Board on 4 October 2000, by the Faculty Board of Technology and Science on 14 June 2006, on 4 September 2008, and on 16 December 2010, and valid from 16 December 2010.

Curriculum Approval

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The PhD programme is offered to the extent permitted by available funding. General stipulations for PhD programmes are provided in the *Higher Education Act* and in the *Higher Education Ordinance.*

1. General Information

Research in physics centres on describing matter and the laws governing its various properties and structures. 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 equipment in research, while theoretical physics uses advanced mathematical tools, for instance. The discipline of physics at Karlstad University offers four doctoral programmes in different research areas.

- materials physics
- theoretical elementary physics and gravitation
- physics education
- systems engineering

In all these areas there is developed cooperation with other universities in Sweden and abroad. In some cases, students pursue doctoral studies within the framework of the national graduate schools. The various research areas are also involved in multidisciplinary projects at Karlstad University, for instance, materials engineering, applied modelling, and mathematics and science education.

In accordance with Karlstad University's equal opportunities policy, gender issues are addressed throughout the programme. Doctoral students are also introduced to multi-disciplinary approaches and involved in interdisciplinary experiences.

2. Aims and Objectives

The general objectives of licentiate or doctoral studies in terms of knowledge and understanding, skills and abilities, and judgement and approach are specified as follows in the *Higher Education Ordinance, attachment 2, SFS* 2006:1053):

Knowledge and understanding

For a degree of Licentiate research students must

- demonstrate knowledge and understanding in the field of research, including current specialist knowledge in a defined part of the field and a deeper knowledge of scientific methods in general and of methods in the specific field of research in particular.

For a degree of Doctor research students must
- demonstrate broad knowledge in and systematic understanding of the field of research, together with deep and up-to-date specialist knowledge in a defined part of the field of research; and
- - demonstrate familiarity with scholarly methods in general and with methods in the specific field of research in particular.

Skills and abilities
For a degree of Licentiate research students must
- demonstrate an ability to identify and formulate issues, critically, independently and creatively, and proceeding with scientific precision; to plan a limited research project and other advanced tasks and to carry them out using appropriate methods within specified time limits, so as to contribute to the development of knowledge; and to evaluate this work;
- demonstrate an ability to clearly present and discuss research and research results in dialogue with the scholarly community and society in general, orally and in writing, in both national and international contexts; and
- demonstrate the skills required to independently participate in research and development work and to work independently in other advanced contexts.

For a degree of Doctor research students must
- demonstrate an ability to engage in scholarly analysis and synthesis and in independent, critical examination and assessment of new and complex phenomena, issues and situations;
- demonstrate an ability to identify and formulate issues, critically, independently and creatively, and proceeding with scientific precision, and to plan and, using appropriate methods, conduct research and other advanced tasks within specified time limits, and to scrutinise and evaluate such work;
- demonstrate, in a dissertation, their ability to make a substantial contribution to the development of knowledge by their own research;
- demonstrate an ability to present and discuss research and research results with authority, in dialogue with the scholarly community and society in general, orally and in writing, in both national and international contexts;
- demonstrate an ability to identify their need of further knowledge; and
- demonstrate a potential to contribute to the development of society and support other people’s learning, both in the field of research and education and in other advanced professional contexts.

Judgement and approach
For a degree of Licentiate research students must
- demonstrate an ability to make ethical assessments in their own research;
- demonstrate insight into the possibilities and limitations of science, its role in society and people’s responsibility for how it is used; and
- demonstrate an ability to identify their need of further knowledge and to take responsibility for developing their knowledge.

For a degree of Doctor research students must

- demonstrate intellectual independence and scholarly integrity and an ability to make ethical assessments relating to research; and
- demonstrate deeper insight into the potential and limitations of scholarship, its role in society and people's responsibility for how it is used.

Licentiate dissertation/doctoral dissertation

For a degree of Licentiate the research students must have received a pass grade on a scholarly dissertation of at least 60 ECTS credits.

For a degree of Doctor the research students must have received a pass grade on a doctoral dissertation of at least 120 ECTS credits.

Subject Specific Objectives

The general objectives for doctoral studies stated above are applied to each of the research areas materials physics, theoretical elementary particles and gravitation, and systems engineering.

In addition to the general objectives, licentiate students in physics must also

• demonstrate awareness of possible career paths for physicists

and doctoral students must also

• demonstrate awareness of possible career paths for physicists in academic teaching and research as well as in the private and public sectors.

3. Admission Requirements

Applicants to doctoral studies must meet the general admission requirements as well as the specific admission requirements and be judged to have the ability otherwise required to pursue the programme successfully (*Higher Education Ordinance*, Ch.6).

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.6).

3.2. Special eligibility

A person who has a Master's degree with a Major in physics with a specialisation in relevant area has special eligibility for admission to doctoral studies in physics. Also eligible is a person who has a Master's degree with the equivalent specialisation in a relevant physics area such as a Master of Science degree in Engineering or in Teacher Education. For the doctoral specialisation area systems engineering, also Master's degree students majoring in electrical engineering with a specialisation in relevant area or equivalent specialisation such as a Master of Science in Electrical Engineering have eligibility.

3.3. Transitional Provisions
Students who met the general admission requirements for admission to doctoral studies before 1 July 2007 shall be considered generally eligible for admission to the doctoral level until 30 June 2015 (SFS 2006:1053).

4. Admission Procedure
Applications for admission to doctoral studies are processed in accordance with the procedures prescribed by the Board of Karlstad University.

5. Selection
Candidates will be selected on the basis of their assessed capacity to successfully complete a programme at the doctoral level. In the ranking and selection of the candidates, special attention will be paid to previous studies, especially to the quality of independently documented research or development projects completed at Master's level in the proposed area. Special consideration will also be given to the candidate's possibility to be present and partake in the departmental research environment.

6. Content and Outline
The doctoral programme can lead to a doctoral or licentiate degree. The doctoral degree requires four years of study, the equivalent of 240 ECTS credits, and the licentiate degree two years or 120 ECTS credits. The studies include course work as well as independent thesis work. To earn a doctoral degree in physics, the candidate must complete 60 ECTS credits of course work and a dissertation of 150 ECTS cr. To earn a licentiate degree, the candidate is required to complete 30 ECTS credits of course work and a dissertation of 75 ECTS cr.

Courses offered at Karlstad University and at other universities at home 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 supervisor and the student. 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.

6.1 Courses
Mandatory courses for all doctoral students at Karlstad University must be included in the programme to the extent required by local regulations.

General mandatory course
For the **Licentiate** degree:
The History and Philosophy of Science, 7.5 ECTS credits

For the **Doctor's** degree:
The History and Philosophy of Science, 7.5 ECTS credits, and
Communicating Science, 4.5 ECTS credits

Subject Specific Courses
Mandatory courses in the chosen area are required courses for all doctoral students in the respective fields. For the Doctor's degree the following must be included:

Materials physics:

- Advanced quantum physics 7.5 ECTS cr
- Solid-state physics 7.5 ECTS cr

For the Licentiate degree, the course Advanced quantum physics is required.

Theoretical elementary particles and gravitation:

- Advanced quantum physics 7.5 ECTS cr
- Classical field theory 7.5 ECTS cr
- Quantum field theory 7.5 ECTS cr
- General relativity theory 7.5 ECTS cr

For the Licentiate degree, the course Advanced quantum physics and one more of the above are required.

Systems engineering:

- Systems identification 7.5 ECTS cr.
- Estimation theory 7.5 ECTS cr
- Courses in physics totalling 15 ECTS cr.

For the Licentiate degree, the course Systems identification and a 7.5 credit course in physics are required.

6.2 Doctoral and Licentiate Dissertations

Doctoral students are required to write a dissertation for a doctoral or a licentiate degree, Dissertations should either be a monograph or a unified collection of previously published papers in English. Candidates are required to defend their licentiate dissertation at a seminar and their doctoral dissertation at a public examination. The articles are expected to meet requirements for publication in reputable refereed science journals. In physics, the doctoral dissertation is normally a unified collection of 4-5 articles written in English. The student's own contribution must be clearly distinguishable. Further information is provided by the policy documents "Doctoral Dissertation Requirements" and "Licentiate Dissertation Requirements".

6.3 Supervision

Doctoral students are entitled to advisors in accordance with the principles stated in the current policy document at Karlstad University.

6.4 Individual Study Plan

Each doctoral student must draw up an individual study plan in conjunction with the advisors. The plan should include a realistic estimate of time for course work, thesis work and supervision as well as an introduction to the proposed research field, problem, aim, methodological and theoretical frames, and relevant ethical considerations.

The individual study plan is subject to continual revision (at least once a year).

6.5 Examination

Doctoral students are examined in accordance with the requirements of each individual course syllabus. Doctoral or licentiate dissertations are examined in accordance with the *Higher Education Ordinance* (Ch.6, §§ 40-47) and Karlstad University's current policy document.