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UMEÅ UNIVERSITY

General syllabus for doctoral studies in computational physics

With doctoral degree as goal

Scope: 240 higher education credits
Degree: Doctoral degree
Study level: Third-cycle
Established by: General syllabus established by the Faculty of Science and Technology Board on 2025-09-25
Enters into force: 2025-10-01
Responsible body: Faculty of Science and Technology

This document has been translated from Swedish into English. If the English version differs from the original, the Swedish version takes precedence.

1. Subject Description and Delimitation

Computational physics is the branch of physics that uses numerical methods and computer simulations to study and model physical phenomena and complex systems when analytical solutions are not available. Complex systems consist of many interacting components and exhibit collective behavior that cannot easily be predicted from the properties of individual components. Methods originally developed within statistical physics to understand interactions among many particles have also proven invaluable for analyzing complex living systems. Consequently, modeling of living systems has become an integral part of computational physics. As an interdisciplinary field, computational physics therefore extends beyond traditional physics disciplines and encompasses network science, biological physics, and other related areas.

The research subject of computational physics aims to train doctoral students to develop tools for designing and predicting experiments, modeling critical parameters, and explaining complex physical systems. In doing so, the subject promotes collaboration across traditional scientific disciplines.

To receive a doctoral degree in computational physics, the student must acquire broad expertise in the research field and in the methods and questions driving it forward. This is demonstrated by the ability to conduct research that makes significant contributions.

2. Objectives of the education

2.1 Description of education at current level

The education is at the third-cycle level. The goals for third-cycle education are found in the Higher Education Act, Chapter 1, Section 9a.

2.2 National goals for the degree

The national learning outcomes for the degree can be found in Appendix 2 of the Higher Education Ordinance.

The learning outcomes for the doctoral degree in computational physics are those specified by the Higher Education Ordinance, Chapter 6, Sections 4 and 5 (see Appendix A), where the terms *research field* and *limited area of this research field* refer to computational physics (as defined above) and the doctoral student's specialization, respectively. These learning outcomes are complemented by a gender and equal opportunities perspective which is integrated in the content and organization of the programme. It provides the student with additional insights into how inequality by traditional structures and perspectives can be counteracted.

3. Entry requirements and prerequisites

To be admitted to doctoral education, the applicant must meet both general and specific entry requirements as outlined below and be deemed to have the overall ability required to benefit from the education. (Higher Education Ordinance, Chapter 7, Section 35)

General entry requirements

To fulfil the general entry requirements, the applicant must have qualifications equivalent to a completed degree at advanced level (second-cycle), or completed course requirements of at least 240 ECTS credits including at least 60 ECTS credits at advanced level. The faculty board may, in the case of a specific applicant, consent to an exemption from the general entry requirements, if there are special reasons to do so. (Higher Education Ordinance, Chapter 7, Section 39)

Specific entry requirements

To fulfil the specific entry requirements to be admitted for doctoral studies in computational physics, the applicant must have completed courses of at least 90 credits within the fields of physics, computing science, mathematics, mathematical statistics or closely related subjects, of which at least 30 credits shall be at advanced level. Courses in statistical analysis, quantitative methods or mathematical modelling outside of these subject areas may also be counted.

The requirements for prior knowledge as described above are also considered to be met by those who have otherwise, within or outside Sweden, acquired essentially equivalent knowledge.

4. Selection

Selection among applicants who meet the entry requirements will be made with consideration of their ability to benefit from doctoral education, and is based on the following assessment criteria:

- personal suitability
- previous study results and
- other merits

However, applicants must not be given preference over other applicants in the selection process solely based on the assessment that the applicant can receive accreditation for previous education or professional activities. (Higher Education Ordinance, Chapter 7, Section 41)

Decisions regarding admissions to studies at doctoral level concluding in a doctoral degree are made in accordance with Umeå University's delegation of authority.

5. Content and structure

5.1 General

An individual study plan is to be established for each doctoral student which shall give details of financing, supervision, courses, thesis-related work, etc. The studies shall encompass 240 ECTS credits. A doctoral student can, if desired, pursue a licentiate degree as an intermediate goal.

Doctoral studies that are to be concluded with a doctoral degree shall comprise a net study period of four years and consist of a course component of 45-60 ECTS credits and an academic thesis of 180-195 ECTS credits.

5.2 Content

The content of the programme consists of courses and thesis work. The course part consists of a fixed set of mandatory courses and a variable number of courses individually determined according to the doctoral student's needs. The mandatory courses convey generic skills, provide an overview of the field as such and its scientific methods, and include gender and equality issues as integral parts. Depending on the specialization and the doctoral students' previous knowledge, the admission decision shall specify additional mandatory course requirements if such is deemed necessary to guarantee that the student achieves a good overall expertise of the subject, and deep knowledge in their particular area of specialization. The annual review of the doctoral student's individual study plan ensures an appropriate selection of courses and other activities to achieve the national goals for doctoral education."

The character of the education is highly international. Doctoral students participate in international collaborations, and are expected to present their research results in international contexts.

5.2.1 Courses

The following courses are mandatory for all doctoral students in computational physics:

Mandatory courses developing general competence:

- *Introduction to Doctoral Studies at the Faculty of Science and Technology*, 1 ECTS credit
- *Writing Science*, 5 ECTS credits
- *Oral Presentation*, 1 ECTS credit
- *Science, ethics and society, 4 ECTS credits*
- *Physics seminar, 4 ECTS credits*
- *Physics, knowledge, gender, 3 ECTS credits*

Additional mandatory courses for the individual doctoral student can be specified in the admission decision.

Elective courses that deepen the doctoral student's expertise in computational science
The remaining course requirements are satisfied with elective courses relevant for the studies, which broaden or deepen the doctoral student's expertise in the subject (at least 30 ECTS credits) or provide additional generic skills.

5.2.2 Doctoral thesis

Through the doctoral thesis, the doctoral student shall demonstrate that the national goals for the doctoral degree have been achieved.
The doctoral thesis comprises 180-195 ECTS credits. It may either take the form of a single coherent work (a monograph) or a compilation consisting of an introduction, a number of

scientific papers, and a summary and discussion of the papers which includes a description of the author's contributions to each paper (compilation thesis). Further, the thesis shall contain a popular scientific description aimed at readers outside academia.

The doctoral thesis shall be defended orally in public, resulting in an assessment with one of the following grades: G (Pass) or U (Fail). When setting the grade, the grading committee shall pay attention to both the content of the thesis and its defense.

6. Examination

The doctoral degree is awarded upon completion of doctoral studies equivalent to 240 ECTS credits, provided that the applicant has received the grade *Pass* in all mandatory parts. In particular, this includes the public defense of the doctoral thesis and its approval by the grading committee. Degree certificates are issued following application to Student Services/Examina.

7. Other instructions

The provisions that apply in respect of doctoral studies can be found in:

- The Higher Education Ordinance: Chapter 5 Employment of doctoral students, Chapter 6 Courses and study programmes, and Chapter 7 Admission to courses and study programmes, Annex 2 Qualifications ordinance.
- Admission regulations for doctoral education at Umeå University.
- Local degree ordinance at Umeå University.
- Rules for doctoral education at Umeå University.
- Handbook for doctoral studies at the Faculty of Science and Technology at Umeå University.

Appendix A

Learning outcomes for the doctoral degree

(Higher Education Ordinance, Chapter 6, Sections 4 and 5)

Knowledge and understanding

For the doctoral degree, the doctoral student shall

- demonstrate broad knowledge and systematic understanding of the research field as well as advanced and up-to-date specialized 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 doctoral degree, the doctoral student shall

- demonstrate the capacity for scholarly analysis and synthesis as well 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 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 in 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 doctoral degree, the doctoral student shall

- demonstrate intellectual autonomy and disciplinary rectitude as well as the ability to make assessments of research ethics, and
- demonstrate specialized insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how this is used.