Reg. no HNT 2022/666

Faculty of Health, Science and Technology

Curriculum for Third-Cycle Education in Mathematics

(Forskarutbildning i matematik)

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Course Approval

The curriculum was approved by the Faculty Board of Health, Science and Technology on 15 December 2022 and is effective from the decision date.

General stipulations for third-cycle education are provided in the Higher Education Act and in the Higher Education Ordinance. The Licentiate/Doctoral programme is offered to the extent permitted by available funding.

1. General Information

Mathematics is one of Karlstad University's research areas and our research is conducted within two specialisations, pure and applied mathematics and mathematics education, and we offer third-cycle education in both strands. Mathematics has been a basis for thinking since time immemorial. Its development has had a strong intellectual driving force, but has also to a great extent been inspired by its applications in physics and technology. This aspect has gained more ground in recent decades and mathematics is now applied to a significant extent in physics, chemistry, technology, medicine, economics, and other social sciences. Modern computer science is also based on mathematics. This has meant a significant expansion of the subject of mathematics in recent decades.
Mathematics is a major subject area, from compulsory school all the way to university. The need for more and broader research on learning and teaching mathematics within the Swedish educational system is well documented. Teachers with expertise in mathematics and mathematics education are in great demand today. This applies to the entire educational system, from compulsory school to university.

Third-cycle education in mathematics includes collaboration with other universities both within and outside of Sweden. In compliance with the Karlstad University gender equality policy, the gender perspective should be included in third-cycle education. Doctoral students should also gain insights into multidisciplinary working methods and experience of meetings across traditional subject boundaries.

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 Higher Education Ordinance, Annex 2, (SFS 2006:1053):

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

The aim of the programme is for the research student to gain knowledge and acquire skills in the areas of knowledge and methods relevant to the specialisation in question. Upon completion of the programme, the aim is also for the student to have contributed new and relevant knowledge to the current research domain in the form of a thesis and to have the ability to conduct independent research within their chosen thesis area. The student should also have some level of orientation in terms of the knowledge traditions and science-based views of other subjects, as well as being able to convey their research findings in an easily comprehensible way. The student should also have some level of orientation in terms of possible career paths upon completion of the programme.

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 credits 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, Chap.7, Sec. 39).

3.2 Special Eligibility

To meet the specific entry requirements for third-cycle education in mathematics, the applicant must hold a Degree of Master (60 or 120 credits) with a major in mathematics and a specialisation in a relevant field, hold a degree with an equivalent specialisation in mathematics, or in some other way have acquired substantially equivalent knowledge, in Sweden or abroad.
To meet the specific entry requirements for third-cycle education in mathematics with a specialisation in mathematics education, the applicant must hold a Degree of Master (60 or 120 credits) that includes courses in mathematics and mathematics education corresponding to at least 90 credits, including a degree project (independent project) of at least 15 credits with relevance to third-cycle education, alternatively have a Bachelor or Master of Education, or equivalent qualifications according to previous programme requirements, with a specialisation in mathematics.

4. Admission
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 with an emphasis on the quality of independent written work of a scholarly and investigatory nature included in the course or programme, particularly at Master's level and within the intended specialisation of the third-cycle education. Completed teacher education or other pedagogical education of similar scope as well as experience as a teacher will be given considerable weight in the admission to third-cycle education in mathematics with a specialisation in mathematics 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).

To earn a licentiate degree, the candidate is required to complete 50 credits of course work and a thesis comprising 60 credits.

To earn a doctoral degree, the candidate must complete 90 credits of course work and a thesis comprising 120 credits.

6.1 Courses
Third-cycle courses are often offered as reading courses. Students can also take courses at other universities. The courses mentioned here are recommended suggestions, they are not mandatory.

General/cross-faculty courses
General and/or cross-faculty courses for all research students at Karlstad University must be included in the programme to the extent required by local/national regulations. Above all, suitable courses should be chosen with regard to the aims and objectives stated in the Higher Education Ordinance's list cited in section 2 of this curriculum.

Examples of course content: Introduction to Research Studies, Ethics, Philosophy of Science, Scientific Writing, Presentation Techniques.

Subject-specific courses
The following are examples of content in the subject-specific courses. Concrete choices of courses should be made in consultation with the examiner and the supervisor, with the aim of creating both broad knowledge and systematic understanding of the research domain, as well as current specialist knowledge within the delimited part of the research domain on which the thesis focuses. Courses are selected with regard to the student's prior knowledge and the

presence of common content in the various courses, among other things.

Courses for a Degree of Doctor or Licentiate in mathematics may include, for example:
Functional Analysis; Measure and Integration Theory; Partial Differential Equation and FEM; Homogenisation: Multiscale Modelling, Analysis and Simulations; PDE-Constrained Optimisation.

Courses for a Degree of Doctor or Licentiate in mathematics education mainly consists of three parts in the areas:
- Mathematics and the history of mathematics with scientific aspects of the subject
- Learning in mathematics and mathematics education as a research domain
- Basic pedagogical theory of relevance to mathematics education research, as well as research methodology and theory in the discipline.

Seminars and conferences
The student is expected to participate in the scientific activities by attending mathematics seminars and guest lectures, even if these are not directly related to any part of the course.
Research students are also expected, as part of their education, to actively participate in seminars and international conferences (i.e. with lectures and/or poster presentations). Following consultation with the supervisor and the examiner, this can award credits, however, no more than 4.5 credits for a licentiate degree and 9 credits for a doctoral degree.

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 papers included in a compilation thesis must be of such academic quality that they meet the requirements for publication in high-quality international journals with a peer review system. The research student's contribution must always be clearly stated. The licentiate thesis is to be defended at a licentiate seminar and the doctoral thesis at a public examination. Further information is provided in policy document *Regulations for Third-Cycle Studies at Karlstad University*. The thesis topic for either degree is chosen in consultation with the supervisor and examiner.

6.3 Supervision
Admitted 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 student shall draw up an individual study plan (ISP) in consultation with their supervisors. 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 written revision (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 assessed 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. 33-35) and Karlstad University's current regulation.