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General syllabus for third-cycle studies in Mathematics TEFMAF00

The syllabus was approved by the Board of the Faculty of Engineering/LTH 21 May 2008 and most recently amended 8 September 2020 (reg. no U 2020/679).

1. Subject description

Mathematics is a science that uses logical inferences to study concepts with well-defined properties laid down in axioms. The classical division of mathematics is into three main branches: analysis, algebra and geometry, between which there is a continual exchange of ideas and results. Concepts, theory formation and methods from these three branches have long been important tools in applications in engineering and science. Over recent decades, the importance of mathematics has further increased as a result of the rapid developments in computer science, which have made it possible to develop and analyse mathematical models for very complicated systems. This has also given rise to new mathematical research problems, which along with the research problems within the discipline help to drive mathematics forward.

Within mathematics at LTH, there is research and third-cycle education on both problems within the discipline and problems motivated by applications in engineering, science and economics.

2. Objective of third-cycle studies at LTH

The Board of LTH established the following objective for third-cycle studies on 15 February 2007.

The overall objective of third-cycle studies at LTH is to contribute to social development and prosperity by meeting the needs of business and industry, academia and wider society for staff with third-cycle qualifications. LTH shall primarily provide education leading to a PhD or licentiate in the fields of LTH's professional degrees. The programmes are first and foremost intended for the further training of engineers and architects. The programmes are designed to encourage personal development and the individual's unique qualities.

Third-cycle graduates from LTH shall demonstrate:
- proficiency in research theories and methods and in a critical, scientific approach
- both breadth and depth of knowledge within the subject of his or her third-cycle studies

The programmes aim to develop:
- creativity and independence with the ability to formulate advanced research issues, solve problems and plan, carry out and evaluate projects within a set time frame
- openness to change
- personal networks, both national and international
- social skills and communication skills
- teaching ability
- innovation skills, leadership and entrepreneurship

In order to enable students to achieve these skills and abilities, LTH provides:
- high-quality supervision and good conditions for study in a creative environment
- a good balance between basic and applied research, with openness to wider society

- a range of advanced third-cycle courses at both departmental and faculty level
- a good balance between courses and thesis work
- opportunities to present research findings at national and international conferences and in internationally recognised journals, or by another equivalent method which leads to wide exposure and circulation
- opportunities to spend time in international research environments for short or extended periods

3. Learning outcomes for third-cycle studies

The learning outcomes for third-cycle studies are given in the Higher Education Ordinance.

3.1 Licentiate

Knowledge and understanding

For a 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 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
- 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 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
- demonstrate the ability to identify the personal need for further knowledge and take responsibility for his or her ongoing learning

3.2 Doctor of Philosophy

Knowledge and understanding

For the degree of Doctor of Philosophy 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
- 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 of Philosophy the third-cycle 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 thesis 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
- 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 of Philosophy the third-cycle student shall:
- demonstrate intellectual autonomy and disciplinary rectitude as well as the ability to make assessments of research ethics
- 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

Midway Review

A midway review, with the aim of reviewing the doctoral student's education in relation to the learning outcomes for the degree in the Higher Education Ordinance, is to be implemented at least once during the doctoral student's programme for all doctoral students whose education is to conclude with a doctoral degree.

4. General and specific admission requirements

4.1 General admission requirements

A person meets the general admission requirements for third-cycle courses and study programmes if he or she:
- has been awarded a second-cycle qualification, or

- has satisfied the requirements for courses comprising at least 240 credits of which at least 60 credits were awarded in the second cycle, or
- has acquired substantially equivalent knowledge in some other way in Sweden or abroad.

The higher education institution may permit an exemption from the general entry requirements for an individual applicant, if there are special grounds. Ordinance (2010:1064).

4.2 Specific admission requirements

A person meets the specific admission requirements if he or she has:
- at least 90 credits of relevance to the subject area, of which at least 60 credits from the second cycle and a specialised project of at least 30 second-cycle credits in the field, or
- a second-cycle degree in a relevant subject

Finally, the student must be judged to have the potential to complete the programme.

Exemptions from the admission requirements may be granted by the Board of LTH.

5. Selection

Selection for third-cycle studies is based on the student's potential to profit from such studies.

The assessment of potential in accordance with the first paragraph is made primarily on the basis of academic results from the first and second cycle. Special attention is paid to the following:
- Knowledge and skills relevant to the thesis project and the subject of study. These may be demonstrated through documents appended to the application and at a possible interview.
- An assessment of ability to work independently and to formulate and tackle research problems. The assessment could be made on

the basis of the student's degree project and a discussion of this at a possible interview.
- Written and oral communication skills
- Other experience relevant to the third-cycle studies, e.g. professional experience.

6. Degree requirements

Third-cycle studies in mathematics can be pursued with a general specialisation or a technical specialisation. The technical specialisation has, in addition to the above, the interdisciplinary objective of developing skills in mathematical modelling in collaboration with an area of application and with input from experts in that field.

Third-cycle studies lead to a PhD or, if the student wishes or if it has been specified in the decision on admission, to a licentiate. The student also has the right to complete a licentiate as a stage in his or her third-cycle studies, but is not obliged to do so.

The requirements for a licentiate are
- passed courses of 45-60 credits, and
- a passed thesis of a scope corresponding to studies of at least 60 credits

The thesis and courses shall comprise at least 120 credits in total.

The requirements for a PhD are
- passed courses of 90-120 credits, and
- a passed thesis of a scope corresponding to studies of at least 120 credits

The thesis and courses shall comprise at least 240 credits in total.

6.1 Degrees awarded

The programme can lead to the following degrees:

- *Teknologie licentiatexamen*/Licentiate in Engineering
- *Teknologie doktorsexamen*/Doctor of Philosophy in Engineering

or:

- *Filosofie licentiatexamen*/Licentiate of Philosophy
- *Filosofie doktorsexamen*/Doctor of Philosophy

7. Course component

The programme is to include courses. For each course, an examiner shall be appointed at the department that delivers the course. The examiner shall draw up a written syllabus which states the course title in Swedish and English, the learning outcomes of the course, the course content and the number of credits.

The individual study plan is to include details of which courses the individual student shall or may include in his or her studies and how many credits for each course may be included in the degree. Courses taken at other faculties or higher education institutions may also be included in the study plan.

It is compulsory to participate in and pass the course Introductory Workshop for Newly Admitted Doctoral Students at LTH *(Introduktionskurs för nyantagna doktorander vid LTH)* GEM056F or the equivalent.

It is also compulsory to attend and earn a Pass grade on the course Research Ethics, GEM090F.

The course component must comprise courses from the following areas of analysis, algebra and geometry:

Analysis: General topology, analytical functions in one and multiple variables, integration theory, functional analysis, spectral theory, distribution theory, harmonic analysis, ordinary differential equations, partial differential equations, dynamic systems, calculus of variations, optimisation.

Algebra: Group and ring theory, Galois theory, linear algebra, representation theory, theory of numbers, commutative algebra, Lie theory, combinatorics

Geometry: Differential geometry, Riemann geometry, differentiable manifolds, differential topology, algebraic topology, algebraic geometry, general and projective geometry

When drawing up individual study plans, the courses are grouped into the following categories A–E:

A. Introductory courses. Depending on prior knowledge, students with an engineering degree take courses in analysis, algebra and geometry that, combined with their previous studies, form a broad and stable foundation for further studies. For other students who intend to follow the technical specialisation, courses shall be selected from fields of engineering to achieve the same aim.
B. Further courses in analysis. Selected from areas not included in A above.
C. Further courses in algebra and geometry. Selected from areas not included in A above.
D. Courses from related fields. Preferably to be selected from mathematical statistics, numerical analysis and computer science.
E. Specialisation courses. To be selected to provide the student with more specialised knowledge in one area, normally the subject of the thesis project. These courses can include third-cycle courses from other disciplines, LTH-wide courses and a project-oriented course in practical mathematics in the form of supervised consultancy work.

As far as resources permit, courses are delivered in the form of lectures and exercises. The courses include exams that may be written and/or oral. The exams are marked as pass or fail.

Students are encouraged to practise their oral and written communication skills during their studies. One way to achieve this is by attending LTH-wide third-cycle courses.

The following guidelines apply to the composition of the course component of the programme.

7.1 Licentiate

Courses of 45-60 credits are required for a licentiate, of which no more than 22.5 credits from A.

7.2 Doctor of Philosophy

Courses of 90-120 credits are required for a Doctor of Philosophy. These are to include no more than 30 credits from A, and 15, 15 and 22.5 credits from B, C and E respectively. For the technical specialisation, at least 15 credits of courses from D are also recommended.

8. Thesis

The programme shall include a research project documented in a licentiate or doctoral thesis.

The research project is to be carried out in a subject included in the Mathematics Subject Classification in Mathematical Reviews; for the technical specialisation it is to include strong elements of mathematical modelling.

Students are to take an active part in the research activities of the department, for example by attending and leading seminars.

8.1 Licentiate thesis

A licentiate is to include a research project corresponding to studies of at least 60 credits, reported in at least one academic paper. This must

be of the standard required for publication in a recognised scientific journal or comparable publication.

The thesis is to be made available at the department for three weeks prior to examination. The project is to be presented at a public seminar during the time the thesis is available for scrutiny. A specially appointed reviewer is also to participate in the seminar.

The thesis is marked as pass or fail. The grade is decided by the examiner.

The thesis should preferably be written in English.

8.2 PhD thesis

The PhD thesis is to be based on an independent research project corresponding to studies of at least 120 credits.

The thesis is to be structured either as a continuous academic work (monograph) or as a short summary of academic articles that the student has authored alone or jointly with others (compilation thesis). The thesis or parts of the thesis are to meet the standards required for publication in recognised scientific journals or comparable publications.

The thesis should preferably be written in English.

9. Transitional provisions

For doctoral students with an admission date of 1 January 2019 or later, it is compulsory to participate in and pass the course Introductory Workshop for Newly Admitted Doctoral Students at LTH *(Introduktionskurs för nyantagna doktorander vid LTH)* GEM056F or the equivalent in order to fulfil the requirements for the degree.

For doctoral students admitted on or after 1 January 2021, it is compulsory to attend and earn a Pass grade on the course Research Ethics, GEM090F.

The midway review is compulsory for doctoral students admitted on or after 1 January 2019.