LUNDS UNIVERSITET
NATUR-
VETENSKAPLIGA
FAKULTETEN

SYLLABUS

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Faculty Board

General syllabus for third-cycle studies in Numerical Analysis NANUMA02

This syllabus was approved by the Board of the Faculty of Science on 16 December 2020 and applies to third-cycle students admitted from 1 January 2021. The syllabus is based on the Higher Education Ordinance (1993:100) Chapter 6 Sections 1–11, 25–36, Chapter 7 Sections 34–41 and Annex 2, the Qualifications Ordinance.

1. Available degrees

The programme described in this syllabus can lead to one of the following degrees:

Doctor of Philosophy in Numerical Analysis / *Filosofie doktorsexamen i numerisk analys*

Licentiate of Philosophy in Numerical Analysis / *Filosofie licentiatexamen i numerisk analys*

In consultation with the Faculty of Engineering, LTH, the Faculty Board has decided (NA35 643/2005) that students admitted to third-cycle studies at the Faculty of Science on the basis of an MSc in Engineering shall be entitled to be awarded the degrees of Doctor of Philosophy in Engineering or Licentiate of Engineering without special application.

2. Subject description

Numerical Analysis comprises two main branches, numerical mathematics and scientific computing, including broad interfaces with mathematics, computer science and the subjects in which it

is applied. Numerical mathematics focuses on the construction and analysis of numerical computational algorithms as well as the development of mathematical software. Scientific computing seeks to solve complex problems within applied mathematics and to develop advanced software systems, which sometimes involves the use of computers or processors with special architecture. The distinction between the two branches is fluid and most research projects include elements of both.

Today, modern computational science and engineering is an essential component of an increasing number of scientific and engineering activities and often constitutes a crucial link in the classical nexus of theory and experiment. As very few mathematically formulated problems can be solved using analytical computation, almost all significant application problems require approximative, numerical computation methods. This applies to approximative solutions of non-linear problems, differential and integral equations, and problems in complex or variable geometry, for example.

The third-cycle programme in Numerical Analysis mainly focuses on these broad issues. The stability, accuracy, efficacy and reliability of the methods are of fundamental importance, as the computations are often particularly extensive and are conducted with finite precision.

The current research areas are described on the departmental website: http://www.matematik.lu.se.

3. Objectives

Third-cycle courses and study programmes shall be based fundamentally on the knowledge acquired by students in first and second-cycle courses and study programmes, or its equivalent. In addition to the requirements for first and second-cycle courses and study programmes, third-cycle courses and study programmes shall develop the knowledge and skills required to be able to undertake autonomous research.

The general outcomes for third-cycle courses and study programmes are defined in the Higher Education Ordinance Annex 2, the Qualifications Ordinance.

3.1 Outcomes for a 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 the ability 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 their 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.

3.2. Outcomes for a 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, and 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 their 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 their ongoing learning.

4. 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.

General admission requirements

A person meets the general entry requirements for third-cycle courses and study programmes if they:

1. have been awarded a second-cycle qualification, or
2. have satisfied the requirements for courses comprising at least 240 credits of which at least 60 credits were awarded in the second cycle, or
3. have acquired substantially equivalent knowledge in some other way in Sweden or abroad.

The head of department may permit an exemption from the general entry requirements for an individual applicant, if there are special grounds.

Specific admission requirements

To be admitted to the third-cycle programme in Numerical Analysis, the student must have passed second-cycle courses in mathematics subjects comprising at least 60 credits, including at least 15 credits in numerical analysis and a degree project of at least 30 credits.

The specific entry requirements can also be fulfilled through an equivalent programme. This is assessed on a case-by-case basis.

Qualifications other than the applicant’s subject-specific competence in Numerical Analysis may be taken into consideration in order to enable interdisciplinary initiatives and important specialisations in certain areas.

5. Selection

In selecting between applicants who meet the requirements, their ability to benefit from the study programme shall be taken into account. However, the fact that an applicant is considered able to

transfer credits from prior courses and study programmes or for professional or vocational experience may not alone give the applicant priority over other applicants.

The following selection criteria will be applied:

Results achieved in first and second-cycle courses or the equivalent. The breadth, depth and relevance of first and second-cycle courses or the equivalent. The quality of the degree project and other autonomous work.

Other knowledge or skills of relevance to the research specialisation.

Suitable candidates should be called to an interview, if possible.

The recruitment and selection for third-cycle studies must always take diversity and gender balance into account, in compliance with Lund University's policy for gender equality, equal opportunities and diversity. The underrepresented gender shall be given precedence in cases of equal qualifications, unless there are valid reasons to the contrary.

Furthermore, it must be possible for the department to offer expert supervision in the student's research specialisation.

6. Degree requirements

The third-cycle study programme concludes with a Degree of Doctor of Philosophy or, if the third-cycle student so wishes or if this is stated in the admission decision, a Degree of Licentiate. The student may also but is not obliged to complete a Degree of Licentiate as a stage in the third-cycle programme leading to a Degree of Doctor.

The Degree of Doctor comprises 240 credits and the Degree of Licentiate 120 credits.

For a Degree of Doctor or Licentiate, the research student must have successfully completed a PhD or Licentiate thesis and passed all courses and other components specified below.

6.1. Thesis

The programme is to include a research project documented in a PhD or Licentiate thesis. The thesis is to be defended at a public defence (Degree of Doctor) or a public seminar (Degree of Licentiate), which both have a reviewer.

PhD thesis

The PhD thesis is to comprise at least 135 credits.

The doctoral thesis is to be a thought-out and reasoned discussion of the student's own work in relation to the broader research area, and can be produced either as a *compilation thesis* or a *monograph.*

A compilation thesis consists of copies of a number of research articles or manuscripts and a summarising chapter. The research articles must be of a quality required for publication in recognised peer-reviewed journals and it must be possible in the thesis to determine the doctoral student's contribution to the articles.

In a compilation thesis it is rarely the case that research papers are solely authored by the doctoral student. Emphasis must therefore be placed on the summarising chapter, which on the one hand provides the doctoral student with the opportunity to demonstrate autonomous and independent intellectual performance, and on the other hand enables the assessment of the doctoral student's autonomous and independent contributions. The summarising chapter must provide an introduction to the papers and situate research issues and findings in a broader context. It must therefore be written in a different form to the papers included in the thesis in order to be read as an independent scholarly text. The summarising chapter must not contain extensive duplication of text, figures and tables from the papers.

A monograph thesis is a unified report including descriptions of the research tasks, research issues, methods, analysis, findings and discussion. In particular, the monograph thesis is to present the student's own research in such a way that the methods

applied, findings obtained and conclusions drawn can be understood and assessed.

The thesis must relate to the outcomes defined in the Higher Education Ordinance, which means that the aim of the compilation thesis and the monograph is mainly to:

– demonstrate current specialist knowledge as well as a broad and deep understanding of the research field
– demonstrate the ability to situate the thesis within a broader theoretical and research context
– clearly state the aim of the thesis including its main hypotheses and research issues
– demonstrate familiarity with the methods and analytical tools used in the field of research as well as the ability to assess and evaluate them
– demonstrate the ability to reflect on the significance and limitations of their own research
– significantly contribute to the formation of knowledge in the field and identify the need for further knowledge.

The thesis must contain a popular science summary, which can be written in Swedish or English.

Licentiate thesis

The Licentiate thesis must comprise at least 60 credits.

The Licentiate thesis can either be written as a summary of at least one research article (or manuscript), which the doctoral student has authored alone or in cooperation with others, or as a unified research report (monograph). The thesis must be of a quality required for publication in recognised peer-reviewed journals and it must be possible to determine the contributions of different authors. For more information on summary and monograph theses, see the compilation thesis and monograph thesis sections above.

6.2. Courses and other programme components

The courses and other components of the third-cycle programme in Numerical Analysis at the Faculty of Science are to comprise 75–105 credits for a Degree of Doctor and 30–60 credits for a

Degree of Licentiate. The exact scope of the course requirement is to be specified in the individual study plan.

The programme's courses and other components can be taken at the department, at other departments within or outside the faculty or at other higher education institutions.

The following applies for a Degree of Doctor in Numerical Analysis

1. Compulsory courses and other components

- Faculty-wide introductory course for doctoral students, 0.5 credits
- Introductory course for doctoral students in Mathematics, at least 1 credit
- Research Ethics, 3 credits
- Midway review, 15 credits based on one of the following options:
    - Midway seminar to present preliminary findings, including oral presentation
    - Licentiate thesis defence seminar in accordance with the requirements for a degree of Licentiate in Numerical Analysis

Training in teaching and learning in higher education corresponding to 3 credits is compulsory for doctoral students who teach.

2. General subject literature and courses providing specialised knowledge (at least 30 credits)

Courses may, for example, be selected from the following areas: Numerical Analysis in general, but also more widely from advanced mathematics, such as Functional Analysis, Partial Differential Equations and Statistics.

Optional courses and other components considered relevant by the departmental representative

Courses may, for example, be selected from suitable subjects with a close numerical connection, such as Automatic Control, Computer Science, Climate Science, Physics and Mechanics.

The following applies for a Degree of Licentiate in Numerical Analysis

1. Compulsory courses and other components

– Faculty-wide introductory course for doctoral students, 0.5 credits
– Introductory course for doctoral students in Mathematics, at least 1 credit
– Research Ethics, 3 credits

Training in teaching and learning in higher education corresponding to 3 credits is compulsory for doctoral students who teach.

2. General subject literature and courses providing specialised knowledge (at least 15 credits)

Courses may, for example, be selected from the following areas: Numerical Analysis in general, but also more widely from advanced mathematics, such as Functional Analysis, Partial Differential Equations and Statistics.

Optional courses and other components considered relevant by the departmental representative

Courses may, for example, be selected from suitable subjects with a close numerical connection, such as Automatic Control, Computer Science, Climate Science, Physics and Mechanics.