LUND UNIVERSITY | LTH FACULTY OF ENGINEERING

General syllabus for third-cycle studies in Electrical Engineering TEEITF00

The syllabus was approved by the Board of the Faculty of Engineering/LTH 22 March 2013 and most recently amended 12 March 2019 (reg. no U 2019/104).

1. Subject description

Electrical Engineering at LTH comprises electromagnetic field theory, electronics, networks, security, signal processing, and wireless and wireline communication. The aim of research within the field is to arrive at an understanding of the underlying physical context through theoretical and experimental methods, and to formulate, realise and verify effective solutions in different applications.

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 education 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, 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 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.

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, 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 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, 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 of Philosophy 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.

4. General and specific admission requirements

A person meets the general admission requirements for third-cycle courses and study programmes if he or she:

1. has been awarded a second-cycle qualification
2. has satisfied the requirements for courses comprising at least 240 credits of which at least 60 credits were awarded in the second cycle, or
3. 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).

A person meets the specific admission requirements if he or she has:

1. at least 60 second-cycle credits in subjects of relevance to electrical engineering, or
2. a MSc in Engineering in biomedical engineering, computer science, electrical engineering, engineering mathematics, nanoengineering, engineering physics or information and communication engineering.

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:

1. 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.
2. 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.
3. Written and oral communication skills
4. Other experience relevant to the third-cycle studies, e.g. professional experience.

6. Degree requirements

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 step in his or her third-cycle studies, but is not obliged to do so.

The requirements for a licentiate are
- passed courses of at least 45 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 at least 90 credits, and
- a passed thesis of a scope corresponding to studies of at least 135 credits

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

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.

The general admission requirements for third-cycle studies include a second-cycle degree of at least 240 credits or the equivalent. If a student has a second-cycle degree comprising more than 240 credits, he or she may be permitted to transfer 50 per cent but not more than 30 of the additional credits to the third-cycle programme. Normally, these credits would correspond to the final year of a Master's programme. The courses for which credits are transferred must be relevant to the third-cycle programme. The credits transferred will shorten the third-cycle programme correspondingly (e.g. 30 credits correspond to 6 months).

7.1 Licentiate

For a Licentiate, the course component comprises 45 credits, at least 7.5 of which must be from courses listed in Section 7.3.

7.2 Doctor of Philosophy

For the degree of Doctor of Philosophy, the course component comprises 90 credits, including any credits transferred in accordance with the section above. The aim of the course component is to provide the doctoral student with increased expertise both in the specific research area and in the field of electrical engineering in general, and with basic research skills. The individual selection of courses is generally to comprise four different categories of courses reflecting both breadth and depth of knowledge. The following are basic guidelines, from which there may be considerable individual deviations in terms of credits transferred, the nature of the research project, etc.:

- At least 7.5 credits must be from general courses in accordance with Section 7.3
- At least 40 credits should be from general electrical engineering courses in order to achieve sufficient breadth of education
- At least 30 credits should be from courses that are directly relevant to the research project in order to achieve sufficient depth of education
- At least 10 credits should be from disciplines other than electrical engineering in order to encourage cross-disciplinary skills and lateral thinking. Examples of such disciplines are mathematics, philosophy, law and economics.

Section 7.4 lists the subjects that form the core knowledge and methods required to work with the scientific issues within the research groups of the department. These

subjects are to be regarded as a general foundation for both breadth and depth depending on the character of the individual research project.

7.3 General courses

This section describes the general courses for research studies, of which 7.5 credits are compulsory. The aim of the courses is to provide research students with the basic knowledge required to conduct research studies and prepare for a future career. The following faculty-wide courses are examples of general courses:

- Introductory Workshop, 2 credits
- Scientific Information Management, 3 credits
- Technical Writing for Publication, 6 credits
- Project Management in R&D Projects, 4.5 credits (+ 4.5 credits)
- Introduction to Teaching and Learning in Higher Education, 3 credits
- Communicating Science, 5 credits
- Reading Skills and the Discourse of the Research Article, 3 credits
- Vetenskapsteori och forskningsmetodik (Theory of Science and Research Methodology), 4.5 credits
- Teknik, risk och forskningsetik (Technology, Risks and Research Ethics), 4.5 credits

7.4 Recommended courses

The following courses are recommended for their major significance to specific areas of electrical engineering. Depending on the research student's specialisation within electrical engineering, courses from one of the following groups can be selected together with other relevant courses.

Electronic design

The student should specialise considerably in one of the following subjects:

- Digital VLSI design
- Analogue circuits in CMOS technology
- Mixed-signal circuit design
- Nanoelectronics

As these subjects are closely associated, students are advised to include one course in each subject so as to achieve breadth in the area of electronic design. Furthermore, students are advised to include a course in experimental methodology (CAD design or process engineering) amounting to 15 credits.

Information security and cryptology

Students are advised to specialise considerably in some of the following areas (depending on specialisation):

- Mathematics, especially abstract algebra, number theory, probability theory and statistics
- Cryptology, information theory and coding theory
- Theoretical computer science, such as algorithm theory and complexity theory
- Information security in systems and processes, theory and implementation, risk analysis and certification
- Computer systems, programming environments, operating systems and compilers
- Networks and communication protocols

Among other relevant areas are digital communication, signal processing, software systems, digital IC design, automatic control, queuing systems and optimisation.

Networks and distributed systems
The key areas include:
- Stochastic processes
- Optimisation
- Advanced algorithms, complexity, approximation and heuristics
- Queuing theory
- Distributed systems
- Numerical methods
- Discrete mathematics, graph theory, combinatorics etc.
- Automatic control

Among other relevant areas are mathematics, mathematical statistics, software design, simulation, probability theory, game theory, social networks.

Signal processing
For general electrical engineering, students are advised to specialise in most of the following areas:
- Signal processing, especially basic signal processing, advanced signal processing and linear systems
- Estimation and detection theory
- Telecommunication or medical signal processing

Among other relevant areas are mathematics, mathematical statistics, especially matrix theory, and stochastic processes or probability theory.

Theoretical electromagnetics
Students are advised to specialise considerably in the following areas:
- Advanced mathematical and numerical methods
- Antennae and wave propagation
- Microwave theory and technology
- Particle dynamics and electrodynamics
- Direct and inverse scattering theory

Among other relevant areas are accelerator technology, power systems, communication, signal processing, radar technology, measurement technology, functional analysis, partial differential equations, mathematical modelling, materials, photonics.

Communication and information theory
Students are advised to specialise considerably in one or a few of the following areas (depending on specialisation):
- Mathematics, especially probability theory, stochastic processes and matrix theory
- Digital communication
- Information and coding theory
- Estimation and detection theory
- Networks and communication protocols

Among other relevant areas are signal processing, numerical analysis, optimisation, cryptology, queuing systems and automatic control theory.

Wireless communications
Students are advised to specialise considerably in one or a few of the following areas:

- Digital communication
- Estimation and detection theory
- Information and coding theory
- Antenna theory
- Wave propagation

Among other relevant areas are DSP implementation, queuing theory and traffic models, linear systems, automatic control theory, matrix theory, numerical analysis, radio electronics, satellite communication, probability theory, stochastic processes, systems simulation, algorithm theory, optimisation and radio network planning.

8. Thesis

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

A detailed discussion of the orientation of the research project can be appropriate towards the end of the first study year. Usually, the project will require additional literature surveys within one or several specialised areas. Furthermore, research at this level naturally includes keeping up to date with journal publications in the field.

8.1 Licentiate thesis

The licentiate thesis must take the form of a research paper or a scientifically based investigation reporting the results of a research assignment completed by the student. The thesis may be designed as the first complete part of a PhD thesis or as an independent study that can be included in a future compilation thesis. The licentiate thesis is to be reviewed by a specially appointed reviewer and presented at a public seminar.

8.2 PhD thesis

The PhD thesis is intended to demonstrate that the research student has acquired the skills required to independently execute research assignments. In general, the PhD thesis is to be of such a quality that the thesis in its entirety or parts of the thesis (possibly after revision) meet the requirements for publication in an internationally recognised research journal.

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.