REGULATION

Valid from
2017-04-05

Reference number
V-2017-0095 3.2.3
V-2023-0950 3.2.3

Decision-maker
President

Revised as of
2024-02-06

Entity responsible for supervision and questions
The School of School of Electrical Engineering and computer Science

General syllabus for education at third-cycle level in the subject Information and Communication Technology

This regulatory document has been decided by the President (V-2017-0095) pursuant to chapter 6 sections 26-27 of the Higher Education Ordinance. The regulatory document is valid with effect from 05-04-2017 and was last modified on 06-02-2024 (V-2023-0950). The regulatory document regulates the main content of the education, requirements for special qualifications and the other regulations that are needed. The School of School of Electrical Engineering and computer Science is responsible for review and questions about the governing document.

1 Content of the education

1.1 The name of the subject in Swedish and in English translation

Information and Communication Technology (ICT)

1.2 Subject description

Information and Communication Technology spans the entire domain of Information and Communication Technology, from electronic components, circuits and systems and communication networks to services and user experience from the academic fields of Information Technology, Computer Science, and Electrical and Electronic Engineering

1.3 Specialisations

The third-cycle subject area of Information and Communication Technology has the following specialisations:

- Electronic Systems
- Integrated Devices and Circuits
- Communication Systems
- Software and Computer Systems

These are described in greater detail below.

Electronic Systems: The electronic systems specialisation focuses on the design of advanced electronics and embedded and cyber-physical systems. These systems use a variety of technologies, from radio electronics and digital hardware to embedded systems. Research is mainly focussed on methods and tools for design automation as well as on architecture for future cyber-physical systems and systems of systems.

Current research includes the following domains: Formal design methods, tools and architecture for the design of safety-critical multiprocessor systems, communication networks for multi-core embedded and cyber-physical systems, massively parallel reconfigurable architectures, and

hardware security. Research is largely conducted with national and international partners and in close co-operation between academia and industry.

Integrated Devices and Circuits: The main focus of the integrated components and circuits specialisation is on experimental research in micro- and nanoelectronics and solid state electronics and components, including component physics, modelling and process integration. Research also focuses on the use of such components in fabricated ICs, made with either cutting-edge internal or external semiconductor fabrication technology. It also includes theory, analysis, design, methodology, tools and implementation of circuits and systems.

Research is focussed on experimental research on components for future integrated circuits. This includes digital and analogue electronics as well as integrated sensors. The focus of this research is on integrating new material and component concepts on a silicon-based platform to extend IC technology. Research focuses on graphene, SiGe, SiC and III-V technologies in combination with established silicon technologies, as well as new metals and oxides.

Components in these materials are used in circuit applications, such as sensor arrays and photonic light sources and detectors, as well as high-temperature electronics and high-voltage switching.

Research is also conducted in CMOS-based ultra-low energy and high-performance circuits and systems for various applications. This also includes biomedical and internet-of-everything components. The main focus is on RF, analogue and mixed-signal circuits and systems using CMOS technology. Research is characterised by an experimental base, with one of Europe's leading university cleanrooms. The Electrum Laboratory has the excellent facilities which are necessary to realise advanced component structures.

Communication Systems: The communication systems specialisation focuses on the theory, design, implementation and evaluation of communication systems and services. In particular, it includes fixed and wireless networks, applications, network- and service-management systems, communication protocols and architectures for communication systems, as well as the economic and regulatory aspects of communication systems.

Research activities in the domain of communication systems cover technological concepts and implementation aspects of all layers, with a particular focus on the physical layer, Media Access and Control (MAC) and network architectures. This includes, but is not limited to: mobile communications and network IP over optical, copper and wireless links; multi-antenna technologies in the form of large arrays, distributed arrays and reflective surfaces;

three-dimensional networks, including connected aircraft, drones and satellites; energy-efficient communications and networks; wireless localisation and sensing; local and inter-domain routing; network architectures and services; network operations and service provision; business models, economics and policy issues. Research is conducted with national and international partners and in close co-operation between academia and industry.

Software and Computer Systems: Software and computer systems (SCS) focuses on fundamental principles for designing and analysing software, computer systems and services. SCS research is divided into five domains: (i) Software engineering, which focuses on methods for developing software systems, such as DevOps, software testing and automatic software

diversification. Research is also conducted into the theories and systems of modelling, programming languages, compilers, formal semantics, machine learning, probabilistic programming, real-time systems, and novel architectures for autonomous and trust-enabled software and services. (ii) Distributed systems, which focuses on developing large distributed systems and algorithms for programming applications in data-intelligent cloud services, big data and data analytics systems. (iii) Machine learning, which focuses on making scalable algorithms and systems used for data analysis, machine learning and data mining in various applications, such as healthcare, drug development, climate research, predictive vehicle maintenance, smart cities and social networks. (iv) Network systems, which focuses on designing, analysing and managing next-generation networks and services, in particular by facilitating the development and management of critical societal network systems to satisfy requirements for performance, reliability and low energy consumption. (v) Network system security, which focuses on making network systems reliable and protecting networks and their users from attack or misuse.

Research in this domain includes a spectrum of security and privacy issues, with an emphasis on wireless and mobile systems, and pays considerable attention to theoretical methods, including formal protocol analysis and information theory results.

The remainder of this document applies to all specialisations.

1.4 Organisation of the education

The individual study plan (ISP) must be updated at least once per year in consultation between the supervisor and the doctoral student.

During their education, doctoral students must participate in and contribute to scientific activity at the school/KTH by attending and participating in seminars.

1.4.1 Activities for fulfilment of outcomes for the education according to the Higher Education Ordinance (HF)

Below are *general suggestions* on how the goals can be achieved. Also note that more *suggestions* can be found in the appendix (taken from the KTH template) which can be found at the end of this document. Students are encouraged to use these in the annual updating of the eISP document.

Learning outcomes: Knowledge and understanding

For the Degree of Doctor the doctoral student shall:

- Demonstrate broad knowledge and a systematic understanding of the research field as well as advanced and up-to-date specialist knowledge in a limited area of this field.

  This outcome can be achieved with the thesis work, as well as through the doctoral student's participation in research seminars and the completion of a number of information and communication technology courses within and outside the domain of specialisation.

- Demonstrate familiarity with research methodology in general and the methods of the specific field of research in particular.

  This outcome can be achieved by completing a course in research methodology, e.g., "The Art of Doctoral Research" as well as through additional activities such as reading, discussing and presenting research articles in the research domain.

For a Degree of Licentiate, the doctoral 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 in particular.

This outcome can be achieved through the dissertation work and the completion of a research methodology course, e.g., "The Art of Doctoral Research" and a number of information and communication technology courses within and outside the area of specialisation, as well as additional activities, such as reading, discussing and presenting research papers in the research domain.

Learning outcome: Competence and skills

For the Degree of Doctor the doctoral 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.

  This outcome can be achieved through participation in research and in research seminars, including presentation of one's own results and reviewing the research of others, e.g., through peer review of results.

- 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.

  This outcome can be achieved by the supervisor gradually delegating to the doctoral student a greater role in proposing research questions and carrying out research activities, and through participation in peer review.

- Demonstrate through a dissertation the ability to make a significant contribution to the formation of knowledge through his or her own research.

This outcome can be achieved by writing a doctoral thesis.

- 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.

  This outcome can be achieved by the doctoral student presenting their research at a number of international conferences and local seminars. Publications in specialised and education-and-outreach journals must also be encouraged, especially in the latter stages of doctoral studies. The outcome regarding written presentation of research is achieved through publication of peer-reviewed articles

- Demonstrate the ability to identify the need for further knowledge.

  This outcome can be achieved by the doctoral student independently reading the necessary research literature to solve problems and relate solutions to previous research.

- 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.

  This outcome can be achieved by the doctoral student participating in some form of teaching, e.g., as a teaching assistant, laboratory assistant or external-workplace supervisor. If participation and teaching in educational activities is made impossible by the form of funding (e.g., scholarship), the doctoral student is encouraged to engage in guest lectures, external-employment supervision and/or participation in activities to attract young people and minorities to technical education

For a Degree of Licentiate, the doctoral 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.

  This outcome can be achieved by the supervisor gradually delegating to the doctoral student a greater role in proposing research questions and carrying out research activities, and through participation in peer

- Demonstrate ability in both national and international contexts to present, discuss research, and research findings in speech and writing and in dialogue with the academic community and society in general.

  This outcome can be achieved, for example, by the doctoral student presenting his/her research at a number of international conferences and local seminars. Publications in specialised and education-and-outreach journals must also be encouraged, especially in the latter stages of doctoral studies.

- Demonstrate the skills required to participate autonomously in research and development work and to work autonomously in some other qualified capacity.

This outcome can be achieved by the doctoral student making a significant contribution to original scientific work that has been or will be published in scientific international journals or peer-reviewed conferences. This outcome can also be achieved through a licentiate thesis based on the doctoral student's own studies of good scientific and linguistic quality, defended and discussed at a licentiate seminar, and given a passing grade by an independent examiner.

Learning outcomes: Judgement and approach

For the Degree of Doctor the doctoral student shall:

- Demonstrate intellectual autonomy and disciplinary rectitude as well as the ability to make assessments of research ethics.

This outcome can be achieved through courses on sustainable development, as well as through participation in peer review. Issues of ethical judgement are naturally inherent in many of the research projects that doctoral students are involved in. This outcome can also be achieved through participation in continuous discussions within their own research group and through reflection, in the thesis, on the ethical aspects of their own research project.

- 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.

  This outcome can be achieved through courses on sustainable development, such as "The Sustainable Scientist" and other courses with an achieved learning outcome related to sustainable development, as well as participation in continuous discussions within one’s research group.

For a Degree of Licentiate, the doctoral student shall:

- Demonstrate the ability to make assessments of ethical aspects of his or her own research.

  This outcome can be achieved through completion of at least two courses on sustainable development, such as "The Sustainable Scientist", and by participating in continuous discussions with supervisors and within other research groups about one's 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.

  This outcome can be achieved through a course in research methodology, such as "The Art of Doctoral Research" and participation in continuous discussions within the research community.

- Demonstrate the ability to identify the personal need for further knowledge and take responsibility for his or her ongoing learning.

This outcome can be achieved by the doctoral student independently studying the research literature needed to solve problems and relate solutions to previous research.

KTH's outcome in sustainable development

For both the Degree of Licentiate and the Degree of Doctor, the doctoral student shall:

- Demonstrate with knowledge and skills the ability to be able to contribute to sustainable societal development towards an equal, inclusive and climate-neutral society.

  This outcome can be achieved through completion of at least two courses on sustainable development, such as "The Sustainable Scientist", among others, as well as by participating in continuous discussions within one's own research group and reflecting, in one's thesis, on the sustainability aspects of one's own research project.

1.4.2 Compulsory courses

For the Degree of Doctor and the Degree of Licentiate, a course in research methodology worth at least 6 credits is compulsory. Doctoral students therefore take the course "The Art of Doctoral Research" or equivalent. This compulsory course includes the following areas:

- Starting out in research: a general introduction and general research methodology. Theme should correspond to at least 3 credits.

- Writing and presentation skills for doctoral students. Theme should correspond to at least 3 credits.

For the Degree of Doctor and the Degree of Licentiate, a course in communication and teaching worth at least 3 credits is compulsory. Doctoral students therefore take the course "Basic Communication and Teaching" or equivalent.

For the Degree of Doctor and the Degree of Licentiate, a course in sustainable development is compulsory. Doctoral students therefore take the course "The Sustainable Scientist" or equivalent. This compulsory course includes the following areas:

- Basic research ethics: the main aspects of sustainable development, gender equality, diversity and equal conditions, and research ethics. Theme should correspond to at least 2 credits.

For the Degree of Doctor and the Degree of Licentiate, a second course with intended learning outcomes in sustainable development must also be taken by the doctoral student. In total, doctoral students must complete at least two courses with intended learning outcomes in sustainable development.

1.4.3 Recommended courses

1.4.4 Conditional elective courses

Doctoral students are encouraged to take a language course (Swedish, if necessary, otherwise English or another language). Language courses should be at university level (first or second cycle) and should not exceed 6 credits.

1.4.5 Requirements for the degree

Degree of Doctor

A Degree of Doctor comprises 240 credits. At least 120 credits must consist of the doctoral thesis

Thesis

Quality requirements and possible other requirements for the thesis.

The thesis must include new research results that the student has developed, alone or in collaboration with others. The main scientific results must meet the quality requirements for publication in internationally recognised peer-reviewed journals. The student must make a distinct contribution to co-authored texts included in the thesis.

The thesis is normally to be written in English. It can either take the form of a compilation of scientific articles or a monograph. In the former case, there must be a specially written summary. Regardless of whether the thesis is intended as a monograph or a compilation thesis, publication of the results achieved, in the form of peer-reviewed articles, should be sought during the doctoral period. Thesis requirements are the same for all Information and Communication Technology specialisations.

Courses

The doctoral student shall have completed courses of at least 60 credits, of which 45 credits must be at third-cycle level and no more than 10 credits can be at first-cycle level.

Degree of Licentiate

A Degree of Licentiate comprises at least 120 credits. At least 60 credits must consist of the academic thesis.

Thesis

Quality requirements and possible other requirements for the licentiate thesis.

A topic for the licentiate thesis must be chosen in consultation with the director of third-cycle education and the principal supervisor and should be related to the research carried out in the division concerned.

The licentiate thesis must include new research results that the student has developed, alone or in collaboration with others. The main scientific results must meet the quality requirements for publication in internationally recognised peer-reviewed journals. The student must make a distinct contribution to co-authored texts included in the licentiate thesis.

The thesis is normally to be written in English. It can either take the form of a compilation of scientific articles or a monograph. In the former case, there must be a specially written summary. Regardless of whether the licentiate thesis is intended as a monograph or a composite thesis, publication of its results in the form of peer-reviewed articles should be sought during the doctoral period.

Courses

The doctoral student shall have completed courses of at least 30 credits, of which 15 credits must be at third-cycle level and no more than 10 credits can be at first-cycle level

1.4.6 Other elements in the education to promote and ensure goal fulfilment

It is compulsory for doctoral students to present at stage seminars, corresponding to 30, 50 (or licentiate degree) and 80 %-degree progress.

Doctoral students pursuing a Degree of Doctor or Licentiate must present their progress, in detail, at a public seminar, or present a licentiate proposal, after completion of approximately 30 per cent of their studies. Doctoral students pursuing a Degree of Doctor must present their progress at a public seminar after completion of approximately 50 per cent of their studies, or choose to take a Degree of Licentiate. Similarly, those pursuing a Degree of Doctor must present a doctoral proposal after completion of approximately 80 per cent of their studies.

The licentiate proposal must include concrete plans for the content and structure of the licentiate thesis, as well as information on how these plans will be implemented to ensure the quality of the licentiate thesis. It is recommended to contact advance reviewers of licentiate theses at the time of the licentiate proposal, to ensure that suggestions for improvements raised at the time of the licentiate proposal are implemented in the final licentiate thesis.

The doctoral proposal must include concrete plans for the content and structure of the doctoral thesis, as well as information on how these plans can be realised to ensure the quality of the thesis. It is recommended to contact advance reviewers of theses at the time of the doctoral

proposal, to ensure that suggestions for improvements raised at the time of the doctoral proposal are implemented in the final thesis.

2 Admission to education at third-cycle level (qualification etc.)

Admission to education at third-cycle level is regulated in Chapter 7, Section 40 of the Higher Education Ordinance and in the admission regulations at KTH. KTH's regulations on specific prerequisites and such abilities in other respects as are needed to assimilate the education in the relevant subject at the doctoral level are set out below.

2.1 Specific prerequisites

To be admitted to the third-cycle education in Information and Communication Technology, the applicant must have passed courses resulting in at least 60 credits at minimum second-cycle level in Information and Communication Technology or other subjects deemed directly relevant to the chosen specialisation. These entry requirements can be also be considered fulfilled by an applicant who has acquired essentially equivalent knowledge in arrangement.

In order to be admitted to third-cycle education in Information and Communication Technology, the applicant must have knowledge of English equivalent to English 6.

2.2 Assessment criteria for testing the ability to assimilate the education

The following assessment criteria apply for testing the ability to assimilate the education:

Selection for third-cycle education is based on assessed ability to assimilate such education. The ability assessment is primarily based on having passed courses and programmes that satisfy the entry requirements. Particular consideration is given to the following:

1. Knowledge and skills relevant for thesis work and the subject.
   These can be shown through attached documents and a possible interview
2. Assessed ability to work independently
   a. ability to formulate and tackle scientific problems
   b. ability to communicate well in speech and writing
   c. maturity, judgement and ability to analyse critically and independently

   The assessment may be based, for example, on degree projects and discussion of these at a possible interview.
3. Other experience relevant for third-cycle education, e.g. professional experience.
   These can be demonstrated through attached documents and, potentially, an interview.

3 The other regulations needed

3.1 Transitional regulations

Doctoral students admitted to a previous general syllabus are entitled to follow either the new syllabus or the syllabus under which they were admitted. Requests to pursue a previous general syllabus, or requests to follow a new general syllabus, are made to the director of third-cycle education. However, changing syllabi requires that the new syllabus can be achieved in time.