



General syllabus third-cycle subject

Subject	Adopted	Registration number	Ks-kod
Machine design	25 Jan 2011	V-2018-0672	3.2.3
	<i>Revised 13 Jun 2018</i>		

General syllabus

Adopted by the faculty council/education committee: 25 Jan 2011

Revised: 13 Jun 2018

Subject title in Swedish (and English translation)

State also whether the subject has specialisations.

Maskinkonstruktion (Eng. Machine Design)

The subject has the following specialisations:

System and component design.

Internal combustion engines.

Mechatronics and embedded control systems.

Integrated product development.

Product and service design.

Subject description – Main content of the programme

At KTH, *Machine Design* deals with the development and design of machines and technical products from a wide, boundary-crossing perspective. The aim is education oriented towards efficient and innovative product development. This is of strategic importance for Swedish industry. Product development covers many different activities and includes the taking into account of technical issues as well as those of a financial and social nature. The combination of these different aspects is essential for successful product development.

In Machine Design, knowledge and engineering ability are of central importance as regards devising complex mechanical and mechatronic components and systems. To generate financial gain, product development normally takes place in an organisational setting. Thus, the strategy, organisation and methodologies of the associated activities are important. The human role in technical systems (e.g. as commissioner, developer or user) is fundamental in product development. Consequently, it is also an integral part of the subject. Research in Machine Design primarily covers the following areas:

- High-performance mechanical and mechatronic components and systems.
- Physical phenomena that can limit or facilitate new designs.
- Design methodology and development methods for composite physical and cyber-physical products.
- Product development processes taking into account technical, financial, environmental and organisational considerations.
- Method development in innovative design, user-driven design and service design.
- Product innovation processes with a focus on, amongst other things, technical, financial and social aspects.
- Tools and computer support in development and design.
- Design principles that can generate new functions and new products.

To be able to handle the subject's diversity and complexity, third-cycle education is organised on the basis of a number of distinct specialisations. More specifically, these are: system and component design; internal combustion engines; mechatronics and embedded control systems; integrated product development; and, product and service design. Below, there are brief descriptions of research in these specialisations. Research and education in all the above-mentioned areas are characterised by wide-ranging industrial cooperation and many international collaborations.

System and component design

At the system and component design unit, research is conducted in three interrelated subject areas: machine elements; tribology; and, machine design.

In machine elements, research focuses on sustainable, environment-friendly and energy-efficient components and systems, i.e. roller bearings, slide bearings, gears, couplings, bolted joints, gaskets and various types of lubricants (oils, greases, ionic liquids and water-based lubricants). Energy losses are a considerable element in all generated energy. They stem from frictional losses in moving parts in machines and energy production systems alike. Research in machine elements is directed towards significantly reducing these losses. The mechanical and electronic components now included in ever more machines are increasingly being developed in ways that reduce the electronic-mechanical distinction. Thus, important parts of the research are the development of: machine elements that are more controllable and adaptive; active strategies for machine maintenance; sensor technology for multiparameter measurement; and, tribotronic systems.

Research in tribology is directed towards the modelling and simulation of friction and wear with a holistic perspective of system effects such as emissions, energy efficiency, material hygiene and design.

Research in machine design covers both development and analysis of products. It primarily focuses on problems related to mechanical systems. However, it also takes in connections to/with adjacent systems and environments. In respect of technical systems and components, important elements of the subject are methods and technologies for: behaviour simulation; performance forecasts; dimensioning; and, optimisation. One important research aspect (which takes in various disciplines) is the development of methodologies for more efficient development and analysis of mechanical systems via optimisation of product properties. Statistical, quasi-statistical, kinematic and dynamic models are examples of models that are interesting for behaviour simulation and product-performance forecasting. The applications vary from small to large products and systems, e.g. from small table-based haptic units to winch systems for wave-energy generation. Another important part of the research is building prototypes for: verifying and validating simulation models; and, testing new product concepts.

Internal combustion engines

Internal combustion engine research is largely about combining knowledge in basic subjects with a demanding application that is of great practical importance – the internal combustion engine. The subject deals with piston engines that use internal combustion. In the research, fundamental physics is interfaced with engine technology. The latest research discoveries are covered with the emphasis on global and local environmental issues. Energy supply issues (e.g. biofuel's possibilities and future scenarios) are important starting points for our

operations. These latter are pervaded by the conducting of research aimed at making drive systems more efficient. Thermodynamic and combustion technology studies are carried out using experiments and leading simulation programs for both 1D and 3D calculations. The unit has a modern engine laboratory at its disposal. The environmental properties, combustion and thermodynamics of current engines are studied. The regulation and development of control systems is an area that is brought to the fore.

Mechatronics and embedded control systems

Software and electronic developments have brought a dramatic change to machine technology. Computer systems are increasingly being built into mechanical products (said systems then being referred to as “embedded systems” or “*embedded control systems*”) and used to create entirely new types of machines and products. This entire area is known as *mechatronics*. Examples of application areas include: active safety systems in vehicles; industrial robots; robot lawn mowers; and, medical equipment such as ventilators or surgical instruments. All these examples include computer-based systems that (using measurement data from sensors, embedded logic, control algorithms and operator/user input) control the machine’s behaviour via various types of actuators and mechanisms. An ever greater part of product functionality is being realised in this way through software. Control systems are often designed as embedded, distributed systems linked (both internally and to the surroundings) in a network. Constant improvement of sensors, actuators and calculation technologies is opening the door to new properties and enhanced performance. Besides pure, functional enhancements, mechatronics and embedded control systems also offer new possibilities as regards diagnostics, adaptivity and support for maintenance and any upgrading or downgrading. This development is being driven onwards by improvements in inter-machine communication and communication with data centres. It is becoming possible to achieve: collaboration and coordination on a wider scale (e.g. “intelligent” transport and production systems); and, integration across a machine’s life cycle.

To use this technology successfully, developers and researchers are facing great challenges. Widely varying technologies, competencies and traditions need to be integrated. The implementation of mechatronics and embedded systems is bringing an increasing system complexity that imposes requirements in respect of adequate design methods, tools, designers and competent developers. Methods and tools for co-designing mechanical systems, sensors/engines, control systems and computer systems are important elements in the research domain.

Embedded control systems are most often the subject of severe requirements as regards reliability and cost-efficiency. Full exploitation of software flexibility and complexity also requires: efficient handling of a product’s configuration; flexibility in operation; and, standardised software platforms. These are areas where constantly increasing system complexity presents major challenges to engineering enterprises and researchers – new methodologies, tools and integrated design methods are needed. Throughout development phases, system designers must take into account: conflicting requirements (reliability, performance, flexibility, new functionalities, existing components/functions, etc.); and, possible realisation (mapping) of functions in software and hardware. They must also deal with the close interdependence of the embedded systems, system functions and surrounding mechanics.

Integrated product development

Product development frequently occurs in complex networks of agents with a large number of activities. The agent network may be a formal organisation with determinable structures. However, even in small organisations, the network is usually complex with many agents in the value chain. The challenges in product development are far more than the purely technical. They are also of a disparate nature, for example: identification of user needs; management of software and hardware requirements; business decisions; and, sustainable development. In this context, purpose-oriented organisation of agents and activities is of critical importance for successful product development.

As a research subject, integrated product development centres on organisation and management of technical development work (with a focus on efficient processes). Touching on organisations' and individuals' ability to work innovatively, innovation is a highly central issue in the discipline. The term "integrated product development" can also relate to a concept where product development methodology champions a holistic approach that takes in a host of aspects in product development (e.g. functionality, production friendliness, marketing possibilities, environmental impact, etc.). This holistic approach requires integration between not only the functions and disciplines in an organisation, but also between individuals and organisations. Integration can also relate to combining business and technical possibilities and/or combining product and service. The research subject is strongly linked to this concept and projects often focus on special aspects of the concept.

Research within the integrated product development unit is carried out in close collaboration with industrial companies. Research issues are most often developed on the basis of a company's actual needs. Consequently, research methods are chosen on the need for results to have an immediate use. With the aim of generating knowledge that can affect product development methodologies, the perspective of the designer or of the product developer are often adopted. Research issues vary and include, amongst other things: support methods in product development; environment-friendly product development; product planning; project work; the marketing of functionalities; organisation and management of development operations; disruptive innovation; business-model innovation; and, idea and knowledge management. The following are of the utmost relevance: projects within interdisciplinary, complex, product development; project portfolio management; procedures for concept development; and, integrated product, service and business development.

Product and service design

The goal of product development is the creation of proposals for products and services that offer market competitiveness and which are popularly perceived as attractive, easy-to-use and worthwhile. This orientation sees products and services as an interaction in which the user's needs, life experience and lifestyle are at the centre of research. The taking into account of technical and marketing considerations complements the user-centred perspective. This is a wide area that distinguishes itself from others by focusing on the interaction between the physical product, services and use.

The product and service design specialisation focuses on methods, matter and end results. This entails, for example: method development (e.g. early phases of product development); the design theme's discourse, context and identity; and, empirical studies of products and services (as models or in use).

Interdisciplinary methods and approaches (e.g. “design thinking” and various types of generative methods that can be used generally in creative and innovative operations) are central in design research. Within the subject, there are strong links between man-computer interaction, architecture, aesthetics, ergonomics and work science. As with all of these, design rests on wide foundations where scientific depth is not the same as disciplinary demarcation. Indeed, it builds rather on a capacity for dynamic interaction between part and whole, experiment and analysis and practice and theory.

Programme objectives based on Sweden’s Higher Education Ordinance, Annex 2 – Qualifications Ordinance

Each doctoral student’s individual study plan shall be designed to guarantee the possibility of attaining the qualitative targets in the Higher Education Ordinance and KTH’s objectives. Attainment shall be evaluated for each individual doctoral student. This shall be done annually by monitoring the individual study plan. The latter shall comment on how, vis-à-vis the goals (i.e. targets and objectives), the programme’s courses and thesis work achieve progression. Other activities (e.g. supervision and outward-oriented operations in line with education and public outreach) shall also be factored into this.

State the programme elements for promoting goal attainment. Other details are to be given in an appendix to the subject’s study plan.

Knowledge and understanding

For a Degree of Doctor, the doctoral student shall demonstrate:

- Wide expertise in, and a systematic understanding of, the research domain; and, deep and current specialist knowledge in a delimited part of the research domain.*
- Familiarity with scientific methodology in general and the specific research domain’s methods in particular.*

These intended learning outcomes are attained individually by each doctoral student through:

- Compulsory courses. The purpose of examination in compulsory third-cycle courses is to ensure that each doctoral student has acquired wide expertise in, and systematic understanding of, the research domain and a broad understanding of scientific methodology in general.
- Recommended courses. The recommended courses all satisfy the purpose of further ensuring the doctoral student’s wide expertise, insights and ability in relation to the intended learning outcomes. They do this without reducing (through being made obligatory) the need for space for specialist, optional courses. These latter are established individually with each doctoral student.
- Optional courses. These are normally the specialised, subject-specific courses that each doctoral student attends to improve himself/herself in his/her individual research specialisation and, thereby, ensure his/her: specialist knowledge; specialised methodological know-how; specialised analytical ability; ability to identify and plan research projects; and, ability to identify the need for further knowledge. These courses are identified in consultations between doctoral student and supervisor.

Skills and abilities (communication ability included therein)

For a Degree of Doctor, the doctoral student shall:

- Demonstrate an aptitude for scientific analysis and synthesis, as well as for independent critical*

examination and assessment of new and complex phenomena, issues and situations.

- Demonstrate an ability to critically, independently, creatively and with scientific precision identify and formulate issues as well as plan and use appropriate methods to conduct research and other advanced assignments within given time frames and examine and evaluate this work.*
- Via a thesis, demonstrate an ability to significantly contribute, through own research, to knowledge development.*
- Demonstrate an ability, in both national and international contexts, to authoritatively present and discuss, orally and in writing, research and research results in dialogues with the scientific community and society in general.*
- Demonstrate an ability to identify further knowledge needs.*
- Demonstrate the potential (within research, education and other advanced, professional contexts) to contribute to societal development and others' learning.*

These intended learning outcomes are attained individually by each doctoral student through:

- Compulsory courses. The purpose of examination in compulsory third-cycle courses is to ensure that each doctoral student has acquired a wide ability to undertake scientific analysis and synthesis.
- Recommended courses. The recommended courses all satisfy the purpose of further ensuring the doctoral student's wide expertise, insights and ability in relation to the intended learning outcomes. They do this without reducing (through being made obligatory) the need for space for specialist, optional courses. These latter are established individually with each doctoral student. For the doctoral students who undertake departmental duties and, wholly or partly, do so within first and second-cycle education, basic qualification in teaching and learning in higher education is compulsory. This nurtures wide competence that links in with the goal of supporting others' learning.
- Optional courses. These are normally the specialised, subject-specific courses that each doctoral student attends to improve himself/herself in his/her individual research specialisation and, thereby, ensure his/her: specialised analytical ability; ability to identify and plan research projects; and, ability to identify the need for further knowledge. These courses are identified in consultations between doctoral student and supervisor.
- Successive seminar processing of the doctoral student's research. Having the doctoral student present his/her research at seminars ensures the ability to present and discuss research. Doctoral students are additionally expected to present and discuss research at international conferences.
- Examination via a thesis.

Judgement and approach

For a Degree of Doctor, the doctoral student shall:

- Demonstrate intellectual independence and scientific probity as well as an ability to assess research ethicality.*
- Demonstrate specialised insight into the possibilities and limitations of the discipline, its societal role and the responsibility people bear for how it is used.*

These intended learning outcomes are attained individually by each doctoral student through:

- Compulsory courses. The purpose of examination in compulsory third-cycle courses is

to ensure that each doctoral student has acquired: intellectual independence; scientific probity; the ability to assess research ethicality; and, a broad insight into the discipline's societal role.

- Recommended courses. The recommended courses all satisfy the purpose of further ensuring the doctoral student's wide expertise, insights and ability. They do this without reducing (through being made obligatory) the need for space for specialist, optional courses. These latter are established individually with each doctoral student.

Sustainable development

For a Degree of Doctor, the doctoral student shall:

- Demonstrate knowledge of, and an ability to make, relevant environmental and ethical decisions in order to be able to contribute to sustainable societal development.

These intended learning outcomes are attained individually by each doctoral student through:

- Compulsory courses. The purpose of examination in compulsory third-cycle courses is to ensure that each doctoral student has acquired: intellectual independence; scientific probity; the ability to assess sustainability and research ethicality; and, a broad insight into the discipline's societal role.
- Recommended courses. The recommended courses all satisfy the purpose of further ensuring the doctoral student's wide expertise, insights and ability. They do this without reducing (through being made obligatory) the need for space for specialist, optional courses. These latter are established individually with each doctoral student.

System and component design specialisation

(If the subject offers specialisations, the content below is to be repeated, as necessary, in its entirety for each specialisation.)

Specific entry requirements

Subject knowledge requirements and any language requirements are to be entered here.

KTH's general entry requirements for admission to third-cycle education apply. Doctoral students are expected to be able to study and write scientific English and to speak English fluently.

Selection rules

Admission of students to third-cycle education is decided by the dean/head of the school. The selection basis is the degree of ability to benefit from third-cycle education. In the first instance, selection is based on documented material cited by the applicant. Other decision inputs such as applicant interviews and contacts with previous higher education institutions may also be important. Suitability for third-cycle education is determined by considering: grades; earlier activities; interests; and, capacity for independent judgement and critical analysis.

Content and examination of the course component

Third-cycle education comprises a course component and a thesis requirement:

- A Degree of Licentiate requires 120 HECs, the licentiate thesis providing at least 60 of

these and the course component at least 30.

- A Degree of Doctor requires 240 HECs, the thesis providing at least 120 of these and the course component providing at least 60.

It is recommended that most of the courses are taken in the first years of third-cycle education. However, acquiring specialist knowledge even later may often be relevant.

For each doctoral student, the courses to be studied and the order of these is to be planned. This planning is to be documented in the individual study plan and the courses are to be tied to the knowledge gathering required for research projects. Owing to the doctoral students' different backgrounds, different research objectives and the area's multidisciplinary nature, both second and third-cycle courses may be relevant.

It is relatively usual for research specialisation to lead to knowledge gathering in an area where there are no established courses. Here, it is possible to formulate a literature study course. Such a course is described in terms of goals, delimitations, scope and an implementation plan. It is normally presented in a report and at a seminar. A number of literature study courses offering various credits have been defined for this purpose.

When selecting courses, third-cycle courses given by other university colleges, graduate schools and international networks should be taken into consideration. All courses shall be approved by the doctoral student's principal supervisor and the director of the doctoral programme.

Compulsory and recommended courses

For all Machine Design specialisations, there are two compulsory course requirements. Each doctoral student shall take the introductory course (FMF3021 – 7.5 HECs) and a course/courses offering at total of at least 6 HECs in the areas theory of science and research methodology.

A course in teaching and learning in higher education is a requirement for doctoral students who are to give first and second-cycle teaching.

The following courses are strongly recommended for all Machine Design doctoral students:

- LH200V “Basic communication and teaching” (GKU), 3 HECs, (compulsory for doctoral students who, during their programmes, assist with KTH's first or second-cycle teaching).
- AK3014 “Theory of science and research methodology” – minor course, 3 HECs.
- AK3015 “The persevering researcher”, 2 HECs.
- DS3102 Writing Scientific Articles, 5 HECs.

A course in *product development/design* and/or a course in *systems engineering* is also recommended for all doctoral students in the Machine Design doctoral programme.

For the system and component design specialisation, doctoral students are recommended (in addition to the above) to study courses in:

Machine elements.

Tribology.

Dynamics.

Metrology.

Remaining space for courses is to be used to create the required subject breadth and sufficient individual specialisation. There is a high degree of flexibility when deciding the courses that can be included in the programme. For each doctoral student, the course component shall be planned in consultation with the supervisors and, so that the courses link up with the knowledge gathering that is required in research projects, documented in the individual study plan.

A clear justification of all course selection is to be given in the individual study plan. All courses shall be approved by a supervisor and the director of the doctoral programme. If agreed with the principal supervisor, course points from previous programmes can be credited. In such crediting, regulations in KTH's Qualifications Ordinance for third-cycle degrees shall be observed.

Higher education requirements

Degree of Doctor

The award of a Degree of Doctor requires 240 HECs. The thesis shall provide at least 120 HECs in this.

Thesis

Quality and any other thesis requirements.

A thesis for a Degree of Doctor shall include new theoretical or empirical research results that, in the chosen subject area, the doctoral student has developed via theoretical or empirical research projects. It shall also include an overview of earlier research in the chosen subject area and shall position the doctoral student's contribution in relation to earlier research. Regardless of whether the doctoral thesis is presented as a monograph or as a compilation of scientific papers, it shall be of such quality that it is assessed to equate to at least four papers published in internationally recognised, peer-reviewed scientific journals. In a compilation thesis, the doctoral student should be the lead author of at least one paper.

A monograph thesis shall normally be 80,000 – 100,000 words, this roughly equating to 220 – 260 pages.

Besides a summarising, introductory chapter of normally 30 – 50 pages, a compilation thesis shall include at least four publishable scientific papers (the international standard in this area). At the time of the public defence of the thesis, it is recommended that at least two papers have been accepted for publication in internationally recognised, peer-reviewed scientific journals (conferences also qualify in certain fields).

Courses

A Degree of Doctor in the subject requires 60 HECs from courses.

Degree of Licentiate

The award of a Degree of Licentiate requires at least 120 HECs. The licentiate thesis shall provide at least 60 HECs in this.

Thesis

Quality and any other academic paper requirements.

A thesis for a Degree of Licentiate shall include an application of existing scientific knowledge that, via theoretical or empirical research projects, the student has developed in a new area. It shall also include an overview of earlier research in the chosen subject area and shall position the doctoral student's contribution in relation to earlier research.

Regardless of whether the licentiate dissertation is presented as a monograph or as a compilation of scientific papers, it shall be of such quality that it is assessed to equate to at least two papers published in internationally recognised, peer-reviewed scientific journals.

After approval by the principal supervisor, the licentiate thesis is to be presented at a public seminar in accordance with KTH's rules.

Courses

For a Degree of Licentiate in the subject, courses offering at least 30 HECs are required.

Mechatronics and embedded control systems specialisation

Specific entry requirements

KTH's general entry requirements for admission to third-cycle education apply. Doctoral students are expected to be able to study and write scientific English and to speak English fluently.

Selection rules

Admission of students to third-cycle education is decided by the dean/head of the school. The selection basis is the degree of ability to benefit from third-cycle education. In the first instance, selection is based on documented material cited by the applicant. Other decision inputs such as applicant interviews and contacts with previous higher education institutions may also be important. Suitability for third-cycle education is determined by considering: grades; earlier activities; interests; and, capacity for independent judgement and critical analysis.

Content and examination of the course component

Third-cycle education comprises a course component and a thesis requirement:

- A Degree of Licentiate requires 120 HECs, the licentiate thesis providing at least 60 of these and the course component at least 30.
- A Degree of Doctor requires 240 HECs, the thesis providing at least 120 of these and the course component providing at least 60.

It is recommended that most of the courses are taken in the first years of third-cycle education. However, acquiring specialist knowledge even later may often be relevant.

For each doctoral student, the courses to be studied and the order of these is to be planned. This planning is to be documented in the individual study plan and the courses are to be tied to the knowledge gathering required for research projects. Owing to the doctoral students' different backgrounds, different research objectives and the area's multidisciplinary nature, both second and third-cycle courses may be relevant.

It is relatively usual for research specialisation to lead to knowledge gathering in an area where there are no established courses. Here, it is possible to formulate a literature study course. Such a course is described in terms of goals, delimitations, scope and an implementation plan. It is normally presented in a report and at a seminar. A number of literature study courses offering various credits have been defined for this purpose.

When selecting courses, third-cycle courses given by other university colleges, graduate schools and international networks should be taken into consideration. All courses shall be approved by the doctoral student's principal supervisor and the director of the doctoral programme.

Compulsory and recommended courses

For all Machine Design specialisations, there are two compulsory course requirements. Each doctoral student shall take the introductory course (FMF3021 – 7.5 HECs) and a course/courses offering at total of at least 6 HECs in the areas theory of science and research methodology.

A course in teaching and learning in higher education is a requirement for doctoral students who are to give first and second-cycle teaching.

The following courses are strongly recommended for all Machine Design doctoral students:

- LH200V “Basic communication and teaching” (GKU), 3 HECs, (compulsory for doctoral students who, during their programmes, assist with KTH's first or second-cycle teaching).
- AK3014 “Theory of science and research methodology” – minor course, 3 HECs.
- AK3015 “The persevering researcher”, 2 HECs.
- DS3102 Writing Scientific Articles, 5 HECs.

A course in *product development/design* and/or a course in *systems engineering* is also recommended for all doctoral students in the Machine Design doctoral programme.

For the mechatronics and embedded control systems specialisation, doctoral students are recommended (in addition to the above) to study a selection of the following courses:

- Motion control and dynamics (foundation course in year four at KTH).
- Embedded Control Systems (foundation course in year four at KTH).
- Design of Embedded Control Systems.

- “Model-based system development” – methodology and modelling languages (e.g. UML and SysML), architecture description languages and domain-specific languages.
- “Modelling of dynamic systems”.
- “Continuation courses in control technologies”.
- “Continuation courses in mechanics”.
- “Safety-critical systems”.
- “Formal (computer science) analysis and evidence methods”.
- “Fault-tolerant computer systems”.
- “Autonomous systems”.
- “Robotics”.
- “Co-design of hardware and software”.
- “Computer support, PDM and SCM”.

Remaining space for courses is to be used to create the required subject breadth and sufficient individual specialisation. There is a high degree of flexibility when deciding the courses that can be included in the programme. For each doctoral student, the course component shall be planned in consultation with the supervisors and, so that the courses link up with the knowledge gathering that is required in research projects, documented in the individual study plan.

A clear justification of all course selection is to be given in the individual study plan. All courses shall be approved by a supervisor and the director of the doctoral programme. If agreed with the principal supervisor, course points from previous programmes can be credited. In such crediting, regulations in KTH’s Qualifications Ordinance for third-cycle degrees shall be observed.

Higher education requirements

Degree of Doctor

The award of a Degree of Doctor requires 240 HECs. The thesis shall provide at least 120 HECs in this.

Thesis

A thesis for a Degree of Doctor shall include new theoretical or empirical research results that, in the chosen subject area, the doctoral student has developed via theoretical or empirical research projects. It shall also include an overview of earlier research in the chosen subject area and shall position the doctoral student’s contribution in relation to earlier research. Regardless of whether the doctoral thesis is presented as a monograph or as a compilation of scientific papers, it shall be of such quality that it is assessed to equate to at least four papers published in internationally recognised, peer-reviewed scientific journals. In a compilation thesis, the doctoral student should be the lead author of at least one paper.

A monograph thesis shall normally be 80,000 – 100,000 words, this roughly equating to 220 –

260 pages.

Besides a summarising, introductory chapter of normally 30 – 50 pages, a compilation thesis shall include at least four publishable scientific papers (the international standard in this area). At the time of the public defence of the thesis, it is recommended that at least two papers have been accepted for publication in internationally recognised, peer-reviewed scientific journals (conferences also qualify in certain fields).

Courses

A Degree of Doctor in the subject requires courses offering at least 60 HECs.

Degree of Licentiate

The award of a Degree of Licentiate requires at least 120 HECs. A licentiate thesis shall provide at least 60 HECs in this.

Thesis

A thesis for a Degree of Licentiate shall include an application of existing scientific knowledge that, via theoretical or empirical research projects, the student has developed in a new area. It shall also include an overview of earlier research in the chosen subject area and shall position the doctoral student's contribution in relation to earlier research.

Regardless of whether the licentiate dissertation is presented as a monograph or as a compilation of scientific papers, it shall be of such quality that it is assessed to equate to at least two papers published in internationally recognised, peer-reviewed scientific journals.

After approval by the principal supervisor, the licentiate thesis is to be presented at a public seminar in accordance with KTH's rules.

Courses

For a Degree of Licentiate in the subject, courses offering at least 30 HECs are required.

Integrated product development specialisation

Specific entry requirements

KTH's general entry requirements for admission to third-cycle education apply. Doctoral students are expected to be able to study and write scientific English and to speak English fluently.

Selection rules

Admission of students to third-cycle education is decided by the dean/head of the school. The selection basis is the degree of ability to benefit from third-cycle education. In the first instance, selection is based on documented material cited by the applicant. Other decision inputs such as applicant interviews and contacts with previous higher education institutions

may also be important. Suitability for third-cycle education is determined by considering: grades; earlier activities; interests; and, capacity for independent judgement and critical analysis.

Content and examination of the course component

Third-cycle education comprises a course component and a thesis requirement:

- A Degree of Licentiate requires 120 HECs, the licentiate thesis providing at least 60 of these and the course component at least 30.
- A Degree of Doctor requires 240 HECs, the thesis providing at least 120 of these and the course component providing at least 60.

It is recommended that most of the courses are taken in the first years of third-cycle education. However, acquiring specialist knowledge even later may often be relevant.

For each doctoral student, the courses to be studied and the order of these is to be planned. This planning is to be documented in the individual study plan and the courses are to be tied to the knowledge gathering required for research projects. Owing to the doctoral students' different backgrounds, different research objectives and the area's multidisciplinary nature, both second and third-cycle courses may be relevant.

It is relatively usual for research specialisation to lead to knowledge gathering in an area where there are no established courses. Here, it is possible to formulate a literature study course. Such a course is described in terms of goals, delimitations, scope and an implementation plan. It is normally presented in a report and at a seminar. A number of literature study courses offering various credits have been defined for this purpose.

When selecting courses, third-cycle courses given by other university colleges, graduate schools and international networks should be taken into consideration. All courses shall be approved by the doctoral student's principal supervisor and the director of the doctoral programme.

Compulsory and recommended courses

For all Machine Design specialisations, there are two compulsory course requirements. Each doctoral student shall take the introductory course (FMF3021 – 7.5 HECs) and a course/courses offering at total of at least 6 HECs in the areas theory of science and research methodology.

A course in teaching and learning in higher education is a requirement for doctoral students who are to give first and second-cycle teaching.

The following courses are strongly recommended for all Machine Design doctoral students:

- LH200V “Basic communication and teaching” (GKU), 3 HECs, (compulsory for doctoral students who, during their programmes, assist with KTH's first or second-cycle teaching).
- AK3014 “Theory of science and research methodology” – minor course, 3 HECs.

- AK3015 “The persevering researcher”, 2 HECs.
- DS3102 Writing Scientific Articles, 5 HECs.

A course in product development/design and/or a course in systems engineering is also recommended for all doctoral students in the Machine Design doctoral programme.

For the integrated product development specialisation, doctoral students are recommended (in addition to the above) to study a selection of the following courses:

“Innovation management”.

“Creativity, innovation and entrepreneurship”.

“Qualitative research methodology”.

“Quantitative research methodology”.

Remaining space for courses is to be used to create the required subject breadth and sufficient individual specialisation. There is a high degree of flexibility when deciding the courses that can be included in the programme. For each doctoral student, the course component shall be planned in consultation with the supervisors and, so that the courses link up with the knowledge gathering that is required in research projects, documented in the individual study plan.

A clear justification of all course selection is to be given in the individual study plan. All courses shall be approved by a supervisor and the director of the doctoral programme. If agreed with the principal supervisor, course points from previous programmes can be credited. In such crediting, regulations in KTH’s Qualifications Ordinance for third-cycle degrees shall be observed.

Higher education requirements

Degree of Doctor

The award of a Degree of Doctor requires 240 HECs. The thesis shall provide at least 120 HECs in this.

Thesis

A thesis for a Degree of Doctor shall include new theoretical or empirical research results that, in the chosen subject area, the doctoral student has developed via theoretical or empirical research projects. It shall also include an overview of earlier research in the chosen subject area and shall position the doctoral student’s contribution in relation to earlier research. Regardless of whether the doctoral thesis is presented as a monograph or as a compilation of scientific papers, it shall be of such quality that it is assessed to equate to at least four papers published in internationally recognised, peer-reviewed scientific journals. In a compilation thesis, the doctoral student should be the lead author of at least one paper.

A monograph thesis shall normally be 80,000 – 100,000 words, this roughly equating to 220 – 260 pages.

Besides a summarising, introductory chapter of normally 30 – 50 pages, a compilation thesis

shall include at least four publishable scientific papers (the international standard in this area). At the time of the public defence of the thesis, it is recommended that at least two papers have been accepted for publication in internationally recognised, peer-reviewed scientific journals (conferences also qualify in certain fields).

Courses

A Degree of Doctor in the subject requires courses offering at least 60 HECs.

Degree of Licentiate

The award of a Degree of Licentiate requires at least 120 HECs. A licentiate thesis shall provide at least 60 HECs in this.

Thesis

A thesis for a Degree of Licentiate shall include an application of existing scientific knowledge that, via theoretical or empirical research projects, the student has developed in a new area. It shall also include an overview of earlier research in the chosen subject area and shall position the doctoral student's contribution in relation to earlier research.

Regardless of whether the licentiate dissertation is presented as a monograph or as a compilation of scientific papers, it shall be of such quality that it is assessed to equate to at least two papers published in internationally recognised, peer-reviewed scientific journals.

After approval by the principal supervisor, the licentiate thesis is to be presented at a public seminar in accordance with KTH's rules.

Courses

For a Degree of Licentiate in the subject, courses offering at least 30 HECs are required.

Product and service design specialisation

Specific entry requirements

KTH's general entry requirements for admission to third-cycle education apply. Doctoral students are expected to be able to study and write scientific English and to speak English fluently.

Selection rules

Admission of students to third-cycle education is decided by the dean/head of the school. The selection basis is the degree of ability to benefit from third-cycle education. In the first instance, selection is based on documented material cited by the applicant. Other decision inputs such as applicant interviews and contacts with previous higher education institutions may also be important. Suitability for third-cycle education is determined by considering: grades; earlier activities; interests; and, capacity for independent judgement and critical analysis.

Content and examination of the course component

Third-cycle education comprises a course component and a thesis requirement:

- A Degree of Licentiate requires 120 HECs, the licentiate thesis providing at least 60 of these and the course component at least 30.
- A Degree of Doctor requires 240 HECs, the thesis providing at least 120 of these and the course component providing at least 60.

It is recommended that most of the courses are taken in the first years of third-cycle education. However, acquiring specialist knowledge even later may often be relevant.

For each doctoral student, the courses to be studied and the order of these is to be planned. This planning is to be documented in the individual study plan and the courses are to be tied to the knowledge gathering required for research projects. Owing to the doctoral students' different backgrounds, different research objectives and the area's multidisciplinary nature, both second and third-cycle courses may be relevant.

It is relatively usual for research specialisation to lead to knowledge gathering in an area where there are no established courses. Here, it is possible to formulate a literature study course. Such a course is described in terms of goals, delimitations, scope and an implementation plan. It is normally presented in a report and at a seminar. A number of literature study courses offering various credits have been defined for this purpose.

When selecting courses, third-cycle courses given by other university colleges, graduate schools and international networks should be taken into consideration. All courses shall be approved by the doctoral student's principal supervisor and the director of the doctoral programme.

Compulsory and recommended courses

For all Machine Design specialisations, there are two compulsory course requirements. Each doctoral student shall take the introductory course (FMF3021 – 7.5 HECs) and a course/courses offering at total of at least 6 HECs in the areas theory of science and research methodology.

A course in teaching and learning in higher education is a requirement for doctoral students who are to give first and second-cycle teaching.

The following courses are strongly recommended for all Machine Design doctoral students:

- LH200V “Basic communication and teaching” (GKU), 3 HECs, (compulsory for doctoral students who, during their programmes, assist with KTH's first or second-cycle teaching).
- AK3014 “Theory of science and research methodology” – minor course, 3 HECs.
- AK3015 “The persevering researcher”, 2 HECs.
- DS3102 Writing Scientific Articles, 5 HECs.

A course in product development/design and/or a course in systems engineering is also recommended for all doctoral students in the Machine Design doctoral programme.

For the product and service design specialisation, doctoral students are recommended (in addition to the above) to study a selection of the following courses:

“Foundation course in design research”.

“Specialisation courses in design research”.

“Practice-based research methodology”.

Remaining space for courses is to be used to create the required subject breadth and sufficient individual specialisation. There is a high degree of flexibility when deciding the courses that can be included in the programme. For each doctoral student, the course component shall be planned in consultation with the supervisors and, so that the courses link up with the knowledge gathering that is required in research projects, documented in the individual study plan.

A clear justification of all course selection is to be given in the individual study plan. All courses shall be approved by a supervisor and the director of the doctoral programme. If agreed with the principal supervisor, course points from previous programmes can be credited. In such crediting, regulations in KTH’s Qualifications Ordinance for third-cycle degrees shall be observed.

Higher education requirements

Degree of Doctor

The award of a Degree of Doctor requires 240 HECs. The thesis shall provide at least 120 HECs in this.

Thesis

A thesis for a Degree of Doctor shall include new theoretical or empirical research results that, in the chosen subject area, the doctoral student has developed via theoretical or empirical research projects. It shall also include an overview of earlier research in the chosen subject area and shall position the doctoral student’s contribution in relation to earlier research. Regardless of whether the doctoral thesis is presented as a monograph or as a compilation of scientific papers, it shall be of such quality that it is assessed to equate to at least four papers published in internationally recognised, peer-reviewed scientific journals. In a compilation thesis, the doctoral student should be the lead author of at least one paper.

A monograph thesis shall normally be 80,000 – 100,000 words, this roughly equating to 220 – 260 pages.

Besides a summarising, introductory chapter of normally 30 – 50 pages, a compilation thesis shall include at least four publishable scientific papers (the international standard in this area). At the time of the public defence of the thesis, it is recommended that at least two papers have been accepted for publication in internationally recognised, peer-reviewed scientific journals (conferences also qualify in certain fields).

Courses

A Degree of Doctor in the subject requires courses offering at least 60 HECs.

Degree of Licentiate

The award of a Degree of Licentiate requires at least 120 HECs. A licentiate thesis shall provide at least 60 HECs in this.

Thesis

A thesis for a Degree of Licentiate shall include an application of existing scientific knowledge that, via theoretical or empirical research projects, the student has developed in a new area. It shall also include an overview of earlier research in the chosen subject area and shall position the doctoral student's contribution in relation to earlier research.

Regardless of whether the licentiate dissertation is presented as a monograph or as a compilation of scientific papers, it shall be of such quality that it is assessed to equate to at least two papers published in internationally recognised, peer-reviewed scientific journals.

After approval by the principal supervisor, the licentiate thesis is to be presented at a public seminar in accordance with KTH's rules.

Courses

A Degree of Licentiate in the subject requires 30 HECs from courses.

Appendix

Qualitative targets (KTH's objectives included therein), as per the Higher Education Ordinance (Appendix 2 – Qualifications Ordinance) for concretising the subject and how the programme is structured to support the attainment of goals (targets and objectives) by doctoral students.

Degree of Doctor

<p>Qualitative targets as per the Higher Education Ordinance (Appendix 2 – Qualifications Ordinance)</p> <p><i>For a Degree of Doctor, the doctoral student shall:</i></p>	<p>Concretisation and adaptation of targets to the third-cycle subject area</p>	<p>Programme elements for promoting goal attainment</p>
<p><i>Demonstrate: wide expertise in, and a systematic understanding of, the research domain; and, deep and current specialist knowledge in a delimited part of the research domain.</i></p>	<p>Demonstrate: wide expertise in, and a systematic understanding of, the machine design research domain; and, deep and current specialist knowledge in a delimited part of the research domain.</p>	<p>Compulsory and recommended courses. Optional subject courses.</p>
<p><i>Demonstrate familiarity with scientific methodology in general and the specific research domain's methods in particular.</i></p>	<p>Demonstrate familiarity with scientific methodology in general and with commonly used methods in the machine design research domain in particular.</p>	<p>Compulsory and recommended courses. Optional methodology courses.</p>
<p><i>Demonstrate an aptitude for scientific analysis and synthesis, as well as for independent critical examination and assessment of new and complex phenomena, issues and situations.</i></p>	<p>Demonstrate an aptitude for scientific analysis and synthesis as well as for independent, critical review and assessment of new and complex phenomena, issues and situations.</p>	<p>Compulsory and recommended courses. Optional methodology courses.</p>
<p><i>Demonstrate an ability to critically, independently, creatively and with scientific precision identify and formulate issues as well as plan and use appropriate methods to conduct research and other advanced assignments within given time frames and examine and evaluate this work.</i></p>	<p>Demonstrate an ability to critically, independently, creatively and with scientific precision identify and formulate issues as well as plan and use appropriate methods to conduct research and other advanced assignments within given time frames and examine and evaluate this work.</p>	<p>Compulsory and recommended courses in research methodology.</p>
<p><i>Via a thesis, demonstrate an ability to significantly contribute, through own research, to knowledge development.</i></p>	<p>Via a thesis, demonstrate an ability to significantly contribute, through own research, to knowledge development in the machine</p>	<p>Approved thesis (following public defence thereof).</p>

<p>Qualitative targets as per the Higher Education Ordinance (Appendix 2 – Qualifications Ordinance)</p> <p><i>For a Degree of Doctor, the doctoral student shall:</i></p>	<p>Concretisation and adaptation of targets to the third-cycle subject area</p>	<p>Programme elements for promoting goal attainment</p>
	<p>design research domain.</p>	
<p><i>Demonstrate an ability, in both national and international contexts, to authoritatively present and discuss, orally and in writing, research and research results in dialogues with the scientific community and society in general.</i></p>	<p>Demonstrate an ability, in both national and international contexts, to authoritatively present and discuss, orally and in writing, research and research results in dialogues with the scientific community and society in general.</p>	<p>Presentation of the doctoral student’s research in seminars. Doctoral students are additionally expected to present and discuss research at international conferences.</p>
<p><i>Demonstrate an ability to identify further knowledge needs.</i></p>	<p>Demonstrate an ability to identify further knowledge needs.</p>	<p>Optional subject courses.</p>
<p><i>Demonstrate the potential (within research, education and other advanced, professional contexts) to contribute to societal development and others’ learning.</i></p>	<p>Demonstrate the potential (within research, education and other advanced, professional contexts) to contribute to societal development and others’ learning.</p>	<p>Recommended courses in teaching and learning in higher education. Recommended participation in the department’s first and second-cycle study courses and programmes.</p>
<p><i>Demonstrate intellectual independence and scientific probity as well as an ability to assess research ethicality.</i></p>	<p>Demonstrate intellectual independence and scientific probity as well as an ability to assess research ethicality.</p>	<p>Compulsory and recommended courses.</p>
<p><i>Demonstrate specialised insight into the possibilities and limitations of the discipline, its societal role and the responsibility people bear for how it is used.</i></p>	<p>Demonstrate specialised insight into the possibilities and limitations of the discipline, its societal role and the responsibility people bear for how it is used.</p>	<p>Compulsory and recommended courses.</p>
<p><i>(KTH’s objectives for ESD) Demonstrate knowledge of, and an ability to make, relevant environmental and ethical decisions in order to be able to contribute to sustainable societal development.</i></p>	<p>Demonstrate knowledge of, and an ability to make, relevant sustainability and ethical decisions in order to be able to contribute to sustainable societal development.</p>	<p>Compulsory and recommended courses.</p>

Degree of Licentiate

<p>Qualitative targets as per the Higher Education Ordinance (Appendix 2 – Qualifications Ordinance)</p> <p><i>For a Degree of Licentiate, doctoral students shall:</i></p>	<p>Concretisation and adaptation of targets to the third-cycle subject area</p>	<p>Programme elements for promoting goal attainment</p>
<p><i>Demonstrate knowledge and understanding in the research domain (current specialist knowledge in a delimited part of this included therein) and specialised knowledge of scientific methodology in general and the specific research domain's methods in particular.</i></p>	<p>Demonstrate knowledge and understanding in the industrial economics and management research domain (current specialist knowledge in a delimited part of this included therein) and specialised knowledge of scientific methodology in general and in the machine design research domain in particular.</p>	<p>Compulsory and recommended courses.</p>
<p><i>Demonstrate an ability to critically, independently, creatively and with scientific precision identify and formulate issues as well as plan and use appropriate methods to conduct a limited research project and other advanced assignments within given time frames and, thereby, to contribute to knowledge development and to evaluate this work.</i></p>	<p>Demonstrate an ability to critically, independently, creatively and with scientific precision identify and formulate issues as well as plan and use appropriate methods to conduct a limited research project and other advanced assignments within given time frames and, thereby, to contribute to knowledge development and to evaluate this work.</p>	<p>Compulsory and recommended courses. Examination through a licentiate dissertation.</p>
<p><i>Demonstrate an ability, in both national and international contexts, to present and discuss, orally and in writing, research and research results in dialogues with the scientific community and society in general.</i></p>	<p>Demonstrate an ability, in both national and international contexts, to clearly present and discuss, orally and in writing, research and research results in dialogues with the scientific community and society in general.</p>	<p>Presentation of the doctoral student's research in seminars. Doctoral students are additionally expected to present and discuss research at international conferences.</p>
<p><i>Demonstrate the skills necessary to independently participate in research and development work and to work independently in other advanced operations.</i></p>	<p>Demonstrate the skills necessary to independently participate in research and development work and to work independently in other advanced operations.</p>	<p>Compulsory and recommended courses.</p>
<p><i>Demonstrate an ability to assess</i></p>	<p>Demonstrate an ability to</p>	<p>Compulsory and recommended</p>

<p>Qualitative targets as per the Higher Education Ordinance (Appendix 2 – Qualifications Ordinance)</p> <p><i>For a Degree of Licentiate, doctoral students shall:</i></p>	<p>Concretisation and adaptation of targets to the third-cycle subject area</p>	<p>Programme elements for promoting goal attainment</p>
<p><i>research ethicality in own research.</i></p>	<p>assess research ethicality in own research.</p>	<p>courses.</p>
<p><i>Demonstrate insight into the possibilities and limitations of the discipline, its societal role and the responsibility people bear for how it is used.</i></p>	<p>Demonstrate insight into the possibilities and limitations of the discipline, its societal role and the responsibility people bear for how it is used.</p>	<p>Compulsory and recommended courses.</p>
<p><i>Demonstrate an ability to identify his or her need for further knowledge and take responsibility for his or her own knowledge development.</i></p>	<p>Demonstrate an ability to identify his or her need for further knowledge and take responsibility for his or her own knowledge development.</p>	<p>Recommended third-cycle courses. Examination through a licentiate dissertation.</p>
<p><i>(KTH's objectives for ESD) Demonstrate knowledge of, and an ability to make, relevant environmental and ethical decisions in order to be able to contribute to sustainable societal development.</i></p>	<p>Demonstrate knowledge of, and an ability to make, relevant sustainability and ethical decisions in order to be able to contribute to sustainable societal development.</p>	<p>Compulsory and recommended courses.</p>