Doctoral programme — Engineering Materials Science

Programme description (KTHTMV)

Programme name
Engineering Materials Science (Teknisk materialvetenskap)

Subject area

The doctoral programme’s overall purpose and learning outcomes
The general aim for the doctoral programme is within KTH's frame for doctoral programmes, that are specified in the regulatory framework. Students graduating from the doctoral programme should, besides having solid subject knowledge within the own research domain, also be able to:

- formulate and initiate research projects
- formulate scientific issues
- carry out research by applying scientific research methodology and put the results in a wider context
- utilise research results in technical applications
- evaluate critically their own and other students' research
- interact efficiently in interdisciplinary research teams through an open approach to other disciplinary domains
- present and discuss research results and research in an educational way within and outside the science community and in educational situations
- apply a research-ethical approach
- lead research projects

The doctoral programme’s size and recruitment
The program is estimated to include 120 doctoral students with a planned recruitment of 25 doctoral students/year and it is primarily directed towards recruiting Swedish and foreign Masters of Engineering (students) with a materials science specialisation, but it also accepts graduates from mechanical engineering, physics and chemistry.

The number of principal supervisors in the program is 24. A list of persons that has the right to be a principal supervisor, including names and subject areas is enclosed, as well as the assistant supervisors that are currently 11 persons.
**Funding**

The program is mainly financed in two ways; partly through the faculty appropriation from KTH, partly by external research funding to individual supervisors being used to finance doctoral students. In addition, a minor share of the doctoral students can be admitted as industry-based doctoral students and be financed by his employers outside KTH.

**Courses**

The courses within the doctoral programme are all offered within a third-cycle subject and are therefore presented in the study plan for the subject.

**Quality enhancement activities**

The program is led of by a programme co-ordinator together with a steering group, whose primary task is to develop the education for third-cycle studies.

The doctoral programme is as a standing item at management group meetings, that are held every second week. Here, the programme co-ordinators bring up specific cases that are current.

Doctoral students'study plans are reviewed and updated regularly. Furthermore, the doctoral students will be expected deliver status reports at least once a year, for review by the three responsible for the doctoral programme. A graphical representation of the reports is used to clarify the individual doctoral student's achievement in relation to what is expected. Like this, possible problems become clear and measures can be taken if necessary. Note that below formula to measure status may be changed.

An important part of the quality assurance procedures is that the doctoral students are expected to publish their results regularly in recognised magazines and to participate actively in international conferences.

Before the public defence of a doctoral thesis, a supplement and draft thesis should be reviewed by an independent anonymous reviewer, who has a Ph.D. or mostly has qualifications to be a docent.

**Norm for doctoral thesis**

Theses can be written as a monograph or a compilation thesis. Normally, the thesis is written in English, but Swedish is also allowed. A thesis should contain new theoretical and/or empirical research results within the field that the doctoral student has chosen to develop via theoretical and empirical research. The thesis should furthermore contain an overview of relevant previous research and position the doctoral student's contribution in relation to previous research.

A monograph should normally include 80,000-100,000 words, i.e. between 220- 260 pages. A compilation thesis should, apart from a summarising chapter of approximately 30-50 pages, include at least four publishable scientific articles (the international norm in the area). The doctoral student should be the responsible primary author of at least one article and the sole author of at least one other article. At the time of public defence of the thesis, at least two articles should furthermore be accepted for publication in internationally recognised scientific magazines with referent review.

**Norm for licentiate thesis**

A licentiate thesis should contain an application of existing scientific knowledge within a new field that the student has developed via theoretical or empirical research. It should also contain an overview of previous research within the chosen subject area and position the doctoral student's contribution in relation to previous research.

Irrespective of the licentiate thesis being presented as a monograph or as a compilation thesis of scientific articles, it should be of such quality that it is assessed to correspond to at least two articles published in internationally recognised scientific magazines with referent review. For a compilation thesis, the doctoral student should be the sole author of at least one article.
After approval from the principal supervisor, the licentiate thesis is presented at a public seminar with an external reviewer/opponent.

**Quality assurance procedures**

Each doctoral student should, besides internal work seminars, present his research at at least three official seminars during the doctoral period:

1. Thesis plan (after about 1 year of studies)
2. Intermediate/licentiate seminar (about halfway)
3. Final seminar (when it is estimated to be 6-12 months left to public defence of the doctoral thesis).

At the intermediate and final seminars, the manuscript is reviewed by an external expert reviewer, preferably a docent. Before the public defence of a doctoral thesis, a complete manuscript together with a proposal for a reviewer and an examination committee should be presented for the supervisor assembly by the principal supervisor. If the faculty meeting finds that the thesis has been produced according to the established that it process and satisfies the quality standards, the faculty meeting is in favour of the thesis being brought further to the public defence.

In addition, the quality assurance routines of KTH and ITM for public defence of doctoral thesis apply.

**National and international network**

Recently accepted doctoral students are given an introduction to postgraduate education to start their work in an efficient way.

Each doctoral student is included a seminar group where progress of the doctoral students' research is regular be discussed.

The doctoral students normally carry out their research cooperation with one or several companies, where contact persons have been appointed.

Once a year, all doctoral students and supervisors are invited to a two-day conference, where opportunity is given to present results, discuss problems and possibilities and to find new cooperations and research approaches. Social activities are also included.

Within the different research teams, regular workshops are arranged, together with company partners and other cooperation partners. The meeting venues alternate between different companies to give both supervisor and doctoral students, and company representatives a possibility to exchange views and discuss results. Experience shows that this type of meetings are considered to be very beneficial.

The successful cooperation with companies, other higher education institutions and research institutes that takes place within the existing program today, will continue and be further developed. The department of Materials Science and Engineering has a very extensive international exchange, which the was noted by the panel at the recently implemented RAE assessment. More specifically, it was reported that 121 registered international cooperations were found. Here, it is limited to cooperations, where joint research funding exist or joint publications have been written. It should been noted that about 7-10 external individuals do research for a period longer than 2 months at the department each year. At the same time, about 4-8 individuals from the department spend at least 2 months doing research abroad each year.

The above is enumerated and defined in appendix 3.

**Further instructions for registration**

The main national contact networks of the doctoral programme include the following universities:

Chalmers Institute of Technology

Dalarna University
Jönköping University
Karlstad University
Linköping University
Luleå University of Technology
Lund University, Faculty of Engineering
Uppsala University

In addition to this, the doctoral programme has a very large international contact network via the involved supervisors. At the recently implemented RAE assessment it was established that the researchers of the department cooperated with 121 foreign departments, see below.

International collaborations

Total number of collaborating departments: 121

Research visits abroad (duration of at least 2 months): 11

Visiting Researchers (duration of at least 2 was months): 37

Appendixes

Appendix 1: Study plan for third-cycle subject Engineering Materials Science (TEMATRVE).
Appendix 2: List containing names and subject areas of supervisors within the programme
Appendix 3: Presentation of the programme’s national and international network
Doctoral programme — Engineering Materials Science

Appendix 1: Study plan for third-cycle subject Engineering Materials Science (TEMATRVE).

The subject plan was approved by Fakultetsnämnden (Faculty Board) June 1, 2010. Valid from Autumn 10.

Subject title
Engineering Materials Science (Teknisk materialvetenskap)

Subject description and programme outcomes

Scientific field
Materials Science treats relationship between behaviour properties, structure and production of different materials. The research includes a large number of types of material, e.g. steel and aluminium alloys, hard metals, ceramics, and magnets and materials for information storing, carbon nanotubes and other types of nanomaterials. The current department of Materials Science and Engineering, created in 1993, is focused on engineering materials. It consists of 12 sections which are divided into three main fields of study: material function, material design and process design.

At the department of Materials Science and Engineering, there have been five third-cycle subject areas since its start in 1993. However, these have during the last decade increasingly been joined to form one single third-cycle subject area. At a study in December 2009 there were 143 active doctoral students with updated study plans and that had an activity of more than 20%. Here, it should be said that there is a large number of industry-based doctoral students, who are connected to the department. The reason is above all strong connections to the industry that supports the third-cycle education in order to increase the skills.

Description of possible specialisation
The subject has no specialisations.

Specification of how the programme outcomes are to be achieved
The general aim for the doctoral programme adheres to KTH's framework for doctoral programmes that is specified in the regulatory framework. Students graduating from the doctoral programme should, besides having solid subject knowledge within their own research domain, also be able to:

- formulate and initiate research projects and formulate scientific issues
- carry out research by applying scientific research methodology and place the results in a wider context
- utilise research results in technical applications and critically evaluate their own and others’ research, and interact efficiently in interdisciplinary research teams through an open approach to other disciplinary domains
- present and discuss research results and research in an pedagogical way, within and outside the science community and in education, and apply a research-ethical approach
- lead research projects

The subject plan was approved by Fakultetsnämnden (Faculty Board) June 1, 2010. Valid from Autumn 10.
Current research
The research is focused on three main fields of study: Material function, Material design and Process design.

Material function
Material function deals with issues that are of crucial importance for the use of material. It includes e.g. design and durability issues, including impact on the environment. To successfully develop new types of materials, these have to be precisely adapted and optimised for the current application. Not the least, this applies to advanced materials, the advantages of which must be fully utilised if they should become competitive. The scientific methods that are used are ab-initio and atomic calculations such as thermodynamic modelling for analysis and development.

Design of Materials
In this subject area, the material properties regarding electron structures are analysed, binding energies, crystal structures, grain boundaries and secondary phase particles and cracks in pores that can sometimes be observed by the naked eye. Without a hierarchical point of view the knowledge of materials becomes incomplete. To be able to design a material with the right properties and behaviours, one must be able to predict the phenomena along many different length and time scales. The aim is to create understanding of microstructure development in materials, with the aim of being able to control it, such that better and better materials can be produced.

Process design
Within Process design, research and development in the area of thermodynamics for the analysis of materials is carried out, in the phase of gas, in liquid phase and in solid form. Thermodynamic modelling is important to find development and applications of tools to calculate reactions in fluid materials and between different gas/fluid, fluid/fluid and gas/gas reactions. New unique calculation tools that dynamically connect kinetics and thermodynamics are developed within the centre for thermodynamic calculations (CCT). Research is carried out to study kinetic and thermodynamic phenomena in melts in melted metals, slags and gases, from some grams to a couple of kgs.

Programme structure
The education for third-cycle studies are carried out under the guidance of one principal supervisor together with one or two assistant supervisors, in accordance with an individual study plan. The education consists of a course module and an thesis module and assumes an active participation in the seminars of the department. The doctoral students normally also have departmental duties, see below.

The third-cycle education is carried out under the guidance of one principal supervisor together with one or two assistant supervisors. The principal supervisor should be a professor, a visiting professor or an adjunct professor, that is employed at KTH. If an adjunct professor is the principal supervisor, he/she should also be docent at KTH. Other individuals that are docent and have a permanent post (tenure) at KTH can also be appointed the principal supervisor.

Assistant supervisors are appointed partly to meet requirements of supplementary specialist competence that can be required for the research specialisation, partly to obtain a supplementary discussion partner for the doctoral student. The assistant supervisor should have a doctoral degree. Assisting supervisors from the industry without a Degree of Doctor, but with good skills can be appointed.

The supervisor is appointed by the Director of Third-Cycle Education at the ITM school after approval by the doctoral programme coordinator of the department. Doctoral students have the right to change supervisor on request, during the third-cycle studies, a decision which is taken in consultation with doctoral programme coordinator. Each doctoral student should have an individual study plan that has been approved by the Director of Third-Cycle Education (FA) of the ITM school. The individual study plan should be adapted to the student's prior knowledge and to the specialisation of the thesis.
The individual study plan constitutes an important document for the planning of the research - the plan can be regarded as a contract between the department and the doctoral student. Creation and update of the study plan are done jointly by the doctoral student, the principal supervisor and the assistant supervisors and it should be updated once a year. In connection to the review of the individual study plan, the doctoral student's progress should be assessed.

The individual study plan should be concrete. This does not exclude that the plan can be incomplete initially, e.g. less specified regarding the latter parts of the education. The study plan should however be detailed for the work of the following year.

The individual study plan is established in connection with the admission to the postgraduate studies and should be delivered to the educational office of the ITM school no later than 6 months after admission. The individual study plan should be updated at least two times a year, preferably more often. An established/updated study plan should be registered in LADOK.

Two times a year, the doctoral student should submit a status report to the doctoral programme coordinator, for checking against the study plan.

Within the framework for third-cycle studies, departmental duties of 20% is normally included (counted over the entire Ph.D. study period), usually by participating in the department's first and second cycle education. Apart from being an important teaching resource, the departmental duties mean that the doctoral student becomes a natural member of the work staff. By participating in the teaching at the department, the doctoral student's pedagogical skills will also be trained.

Parts that may be included in the departmental duties include e.g.:
- Teaching/supervision/grading in courses that are given by the department
- Participation in course development
- Supervision of degree projects, work with web pages, information materials, handling of computer tools, etc.
- Research assignments that are enriching for the doctoral student

The departmental duties are planned in collaboration with the principal supervisor and the department management and should be documented in the individual study plan. The duties should be planned, so that it becomes a natural part of the third-cycle education. If possible, the departmental duties should be planned so that there are less duties during the final stage of the thesis.

In the third-cycle studies, an active participation is required in the research seminars at the department, both the department-specific Higher seminar and the seminar series that are run by different sections and research groups. The doctoral student should present his research at at least two official programme seminars for a Degree of Licentiate (research plan/thesis proposal seminar and final review seminar) and at at least three seminars for a Degree of Doctor (research plan/thesis proposal seminar, intermediate/licentiate seminar and final review seminar).

Participation in conferences constitutes a central element in all third-cycle education.

**Compulsory and recommended courses**

The third-cycle studies consist of a course module and a thesis module:
- For Degree of Licentiate, 120 credits are required, of which the course module should comprise at least 30 credits.
- For Degree of Doctor, 240 credits are required, of which the course module should comprise at least 60 credits.

It is recommended that the majority of the courses are taken during the first years of the third-cycle studies. It can however also be relevant to acquire specialist knowledge later.
By agreement with the principal supervisor can in the individual study plan credits be given for completed first and second cycle courses equivalent to a maximum of 15 credits for a Degree of Licentiate and no more than 30 credits for a Degree of Doctor. Courses from first and second cycle may only given credit for if they deal with subject areas relevant for the third-cycle studies, and only if they do not constitute entry requirements.

Third-cycle courses that are given at other higher education institutions, by national doctoral schools and by international networks should be utilised. All courses should be discussed with the supervisors and approved by the principal supervisor and the programme co-ordinator for the doctoral programme.

At credit transfers, regulations in KTH’s Degree Ordinance for third-cycle degrees should be observed.

**Compulsory courses**

A combination of the following methodology and theoretical courses are compulsory, in all 14 credits of which 8 credits should be included in Degree of Licentiate.

F4H5900 Research planning and supervision 6 credits

Theory of science with special focus on the epistemology of engineering work and industrial activities; ITM general course, 5 credits

Epistemology within engineering, science and innovation; ITM general course, 2 credits

Scientific communication; 6 credits

**Recommended courses**

There is a high grade of flexibility at determination of the courses that should be included in the education. The principle is that the supervisors together with the doctoral student agree on the advanced courses that are most relevant to the doctoral student. These courses are registered in the study plan that is updated regularly following changes decided by the supervisor and the doctoral student. Examples of courses that will be given with regular intervals are:

F4H5202 Deformation mechanisms in metals, 6 credits

FMH3818 Material models at plastic forming

FMH3911 Oxide metallurgy, 6 credits

F4H5617 High Temperature Materials, 6 credits

F4H5622 Material optimisation, 6 credits

FMH3819 Industrial ceramics, 6 credits

F4H5101 Phase transformations, 6 credits

F4H5103 Advanced course in phase transformations, 6 credits

F4H5104 Alloy theory I, 6 credits

F4H5108 Simulation of diffusional transformations, 6 credits

FMH3111 Phase transformations in performance materials, 12 credits

F4H5301 Computer Calculations of Equilibria and Phase Diagrams, 6 credits

F4H5801 Nanomechanics- Methods, Models and Materials, 6 credits

F4H5804 Artificial materials, 6 credits
FMH3910 Quantum metallurgy, 6 credits
FMH3912 Introduction to the EMTO programs package I, 6 credits
FMH3913 Solid State Physics, modelling, 6 credits
FMH3914 Electron structure and atomic scale alloy theory, 6 credits
F4H5806 Nanoscale Materials Innovation Drives Frontiers in Technology, 6 credits
FMH3915 Physical properties of non-perfect crystals, 6 credits
FMH3916 Nanomagnetism, 6 credits
FMH3817 Modelling on atom scale level, 6 credits
F4H5916 Micro modelling in process metallurgy, 6 credits
F4H5923 Fundamental Basis for Modelling of Mass and Heat Transfer, 6 credits
F4H5902 Kinetics, 6 credits
F4H5911 Heat recovery, **3 credits**
F4H5912 Modelling of Industrial Combustion Processes- theory, **7.5 credits**
F4H5913 Modelling of Industrial Combustion Processes- applications, 6 credits
F4H5914 Combustion Engineering, 6 credits
F4H5905 Importance of Inclusions in the Processing of Steel Products, 6 credits
F4H5906 Macro Modelling of Metallurgical Processes I, 6 credits
F4H5907 Reactions with and within Liquid Phases, 6 credits
FMH3901 Application of thermodynamic calculation programs for metallurgical processes, 6 credits
F4H5901 Experimental Techniques in Metallurgy, 6 credits
F4H5904 Theoretical process metallurgy, 12 credits
FMH3253 Fluid Mechanics and heat transfer, 6 credits F4MH5302 the process technology of the Moulding, 6 credits
F4M5307 Solidification Processing I, 6 credits
FMH3820 Reactions in solid phase, 6 credits

**Research skills courses**

The following courses that give academic skills or understanding of significance for the research are strongly recommended to the doctoral students:

F9E5100 Writing scientific papers, 3 credits
FMH3900 Basic supervision of e.g. Bachelor theses, 4 credits

Examples of other courses are teaching and learning in higher education that is recommended for doctoral students that teach:
LH201V Teaching and learning in higher education, 5 credits

As said above, relevant courses can very well be taken at other schools of KTH and at national and international universities. Courses in teaching and learning in higher education are a requirement in the case of teaching in first and second cycle courses during the third-cycle studies.

Thesis

The thesis is a compulsory part of the third-cycle education that aims at the doctoral student developing an ability to independently contribute to the research and the science community. The thesis can either be written as a monograph or as a compilation thesis. In the latter case, the thesis should include a specifically written summary (so-called summarising chapter). Irrespective of form, the thesis is assessed as a whole.

The doctoral thesis can be based on the licentiate thesis

The thesis should normally be written in English or Swedish (for Swedish-speaking theses, special permission from the ITM school is required).

Quality assurance before the public defence of the doctoral thesis

The application for the public defence of the doctoral thesis is made by the principal supervisor to the doctoral programme coordinator, no later than 10 weeks before the date of the defence of the thesis. In connection to this, proposals for faculty opponent and examination committee is also discussed. After that, the doctoral student hands in his supplement and a preliminary thesis to the doctoral programme coordinator, for internal review.

Licentiate thesis

A licentiate thesis should contain an application of existing scientific knowledge within a new field that the student has developed via theoretical or empirical research. It should also contain an overview of previous research within the chosen subject area and position the doctoral student's contribution in relation to previous research.

Whether the licentiate thesis is presented as a monograph or as a compilation thesis of scientific articles, it should be of such quality that it is assessed to correspond to at least two articles published in internationally recognised scientific magazines with peer review.

After approval of the principal supervisor, the thesis is presented at a public seminar.

Doctoral thesis

A thesis for Degree of Doctor should contain new theoretical or experimental research results within the chosen subject area that the doctoral student has developed via theoretical or experimental research. It should also contain an overview of previous research within the chosen subject area and position the doctoral student's contribution in relation to previous research. Whether the doctoral thesis is presented as a monograph or as a compilation thesis, it should be of such quality that it is assessed to correspond to at least four articles published in internationally recognised scientific magazines with peer review.

A compilation thesis should, apart from a summarising chapter, include at least four publishable scientific articles.

The doctoral thesis should be submitted and defended at a public defence of doctoral thesis, according to KTH's general regulations. The thesis is assessed by an examining committee consisting of three or five members, appointed by the ITM school.
Entry requirements and selection

General and special admission requirements and prior knowledge
Qualified to the third-cycle courses and study programmes in Materials science are those that satisfy the following requirements:

General entry requirements for education for third-cycle studies consist of
- degree awarded for second-cycle studies, or completed course requirements of at least 240 credits, of which at least 60 credits should be for second-cycle studies, or in another way within or outside the country acquired equivalent knowledge.

Specific entry requirements apply according to Higher Education Ordinance, chapter 7, section 40. These requirements are set because the doctoral student should be able to absorb the education. The requirements may include:
- knowledge from higher education or the equivalent
- special professional or vocational experience, and
- necessary language skills or other conditions that are determined by the education.

For specific entry requirements at KTH, see Admission regulations for third-cycle studies at KTH. Doctoral students are expected to be able to read and write scientific English and be able to speak English fluently.

Selection rules and procedures
Admission to the third-cycle courses and study programmes in Materials science is decided by the Dean of the ITM school after check of eligibility and suitability by the Director of Third-Cycle Education of the ITM school and acceptance from the Director of doctoral studies at the department.

Suitability for third-cycle courses and study programmes is decided from a combination of grades, previous activities, interest and ability to independent assessment and critical analysis. A connection to the admission a funding plan should be presented for the doctoral student's entire study period (licentiate or doctor), approved by the head of department.

The programme’s degrees and examinations

Degree of Licentiate and Degree of Doctor (PhD)
For Degree of Licentiate, 120 credits are required, of which the course module should comprise at least 30 credits. The licentiate thesis should be submitted in accordance with KTH's general regulations. After approval by the principal supervisor, the thesis is presented at a public seminar. Since the principal supervisor is the examiner, he must/she be docent and employed on KTH.

For Degree of Doctor, 240 credits are required, of which the course module should comprise at least 60 credits. Courses and thesis that are included in Degree of Licentiate may also be included in Degree of Doctor. The doctoral thesis should be submitted and defended at a public defence of the doctoral thesis, according to KTH's general regulations. The thesis is assessed by an examining committee consisting of three or five members appointed by the ITM school.

The programme’s examinations
Courses for third-cycle studies a written examination, an oral examination or a project assignment should be included. The design of the examination should in each individual case be such that examiner ensures that the student has acquired all course content. The examiner in courses for third-cycle studies should be employed as teacher at KTH.
Doctoral programme — Engineering Materials Science

Appendix 2: List containing names and subject areas of supervisors within the programme

The programme description was approved by Fakultetsnämnden (Faculty Board) June 1, 2010. Valid from Autumn 10.

Principal supervisors:

Professors

Stefan Jonsson (MF), Börje Johansson (MD), Levente Vitos (MD), John Ågren (MD), Staffan Hertzman (MD), Mikhail Dzugotov (MD), Bill Bergman (MD), PålÅ®nsson (PD), Lage Jonsson (PD), Włodek Blasiak (PD), Du Sichen (PD).

Senior lecturers:

Rajeev Ahuja (MD), Anna Delin (MD), Malin Selleby (MD), Ragnhild Aune (PD)

Docents:

Lyuba Belova (MD), Clas Persson (MD), Valter StrÅ¶m (MD), Pavel Korzhavy (MD), Weihong Yang (PD), Taishi Matsushita (PD), Margareta Andersson (PD), Andrey Karasev (PD), Teng Lidong (PD), Attila Dioszegi (PD).

Assistant supervisors:

Rolf Sandström (MF), Lai-Zhe Jin (MF), Lars Håglund (MD), Annika Borgenstam (MD), Andrei Ruban (MD), Joakim Odqvist (MD), Peter Hedström (MD), Seshadri Seetharaman (PD), Anders Tillander (PD), Mikael Ersson (PD).

Subject areas according to definition in section 2 are given as follows: Material function (MF); Design of Materials (MD); Process design (PD)
Doctoral programme — Engineering Materials Science

Appendix 3: Presentation of the programme’s national and international network

*The programme description was approved by Fakultetsnämnden (Faculty Board) June 1, 2010. Valid from Autumn 10.*

The main national contact networks of the doctoral programme include the following universities:

Chalmers Institute of Technology
Dalarna University
Jönköping University
Karlstad University
Linköping University
Luleå University of Technology
Lund University, Faculty of Engineering
Uppsala University

In addition to this, the doctoral programme has a very large international contact network via the involved supervisors. At the recently implemented RAE assessment it was established that the researchers of the department cooperated with 121 foreign departments, see below.

International collaborations

Total number of collaborating departments: 121
Research visits abroad (duration of at least 2 months): 11
Visiting Researchers (duration of at least 2 was months): 37