Doctoral programme — Production Engineering

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

**Programme description (KTHIIP)**

**Programme name**

Production Engineering (Industriell produktion)

**Subject area**

The subject area of Production Engineering includes first-cycle courses and second-cycle and third-cycle courses and study programmes, and research in the wide field of production.

The activities cover most central fields in contemporary development of production and manufacturing processes, with close relations to the mechanical engineering industry of today.

Production engineering includes all technology that mainly applies to the production of mechanical products as well as methods that have direct effect on this production.

The field includes everything from design aspects on production to assembly of components into functional products, as well as lifecycle issues in connection with these disciplines.

The topic of production engineering carries out research in four main areas:
- Production metrology
- Adaptive production systems
- Computer systems for design and manufacturing
- Machine and process technology

The research in these areas include, for example:
- Systems, technology and processes for material processing, part manufacturing, verification and assembly
- Methods and aids for design, procurement and development of production systems
- Computer-aids and information management for cooperation in all parts of the product realisation process
- Product design for competitive production
- Industrial metrology
- Production economy

Through the ongoing development of the SRA (strategic research area) XPRES - Excellence in production research - the subject area is increased with complementary scientific skills.

These new fields are:
- Production utilizing new and future materials and methods
- Product and production realisation considering a life-cycle perspective
- Adaptive and flexible production technology

**The doctoral programme’s overall purpose and learning outcomes**

The aim is that the doctoral students should become independent, excellent researchers and leaders in production engineering. The aim of KTH's education at postgraduate (Ph.D./third-cycle) level is to provide the society with qualified researchers that can contribute to a sustainable development of the society. The goal of KTH's education for third-cycle studies is that the doctoral students should become independent, excellent researchers. The research (third-cycle) students should after completed studies be able to:

- describe and explain theories and empirical results within the current field
- formulate concrete research issues within the current field
- use scientific methods and provide new knowledge through own scientific studies
- critically analyse and evaluate applied methods and results from own and others'scientific studies
- present and discuss research results in the scientific community
- present research in an pedagogical way outside the science community and in educational situations
- assess ethical aspects of research within the current field and act from these and
- identify need for new knowledge and have knowledge of how to initiate and lead research

The education for third-cycle studies should also aim against that the doctoral student after completed studies should be able to:

- participate in interdisciplinary cooperations within the current problem area and
- analyse the research role in the development of the society

The principal supervisor together with the doctoral student should at follow up of the individual study plan state how the individual the doctoral student should be able to reach these aims. If the aims have not been satisfied at examination, the principal supervisor should be ready to explain why.

**The doctoral programme’s size and recruitment**

**Number of doctoral students** The program is planned to admit about 6-8 doctoral students a year which give an extent of total about 30-40 doctoral students over five years.

**Student target group** Qualified to be admitted to education for third-cycle studies in Production Engineering are:
- the one that has taken Master of Engineering or Degree of Master of Architecture, or
- the one that has taken other academic qualification for second-cycle studies (Master's degree 60 or 120 credits) or completed course requirements of at least 240 credits, of which at least 60 credits for second-cycle studies, that constitute good preparations for third-cycle studies within production engineering.
- in particular cases, exception from the requirements may be made, if equivalent knowledge can be considered to have been acquired in another way.

Doctoral students are expected to be able to read and write scientific English and be able to talk English fluently.

**Recruitment and admission** Admission to the education for third-cycle studies in Production Engineering is determined by the Dean of the ITM school after evaluation of eligibility and adequacy by the Director of third-cycle studies of the ITM school and approval from the programme co-ordinator of the doctoral programme. Suitability for third-cycle courses and study programmes is decided from a combination of grades, previous activities, interest and ability of independent assessment and critical analysis. In connection with the admission, a funding plan approved by the head of the department, for the doctoral student's entire programme duration should (licentiate or doctor) be presented. Recruitment of doctoral students takes place partly through external advertisements in national and international press, partly by identifying students with good research potential in the Master's education and offer them to apply for such employment. Admission takes place throughout the year. All doctoral students admitted during the previous academic year join at the start of the autumn semester to participate in the introductory third-cycle courses of the program.

**The principal supervisors of the program** To the program, there are currently (september 2010) x professors, visiting professors and docents linked, who can act as principal supervisors (see Appendix 2)

**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**

**Education environment** Doctoral students with Ph.D. student employment are offered the an office (or shared office), full access to computer, printer, office services, etc., and participation in the joint activities of the department, ongoing research projects, seminars, information meetings and similar. For industry-based doctoral students, agreements on the access to infrastructure, office services, etc., are made in each individual case. The intention is that each industry-based doctoral student should spend at least 30% of his working hours at the department.
**Norm for licentiate thesis** A licentiate thesis should include an application of existing scientific knowledge within a new subject area 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 of the principal supervisor, the licentiate thesis is presented at a public seminar with an external reviewer/opponent.

**Norm for doctoral thesis** Theses can be written as monographs or compilation theses. 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. 220-260 pages. A compilation thesis should, apart from a summarising chapter of 30-50 pages, include at least four publishable scientific articles (the international norm within the subject area) of which at least one is in a journal. The doctoral student should be the responsible first author of at least one article and the sole author of at least one other article. At the time of the public defence of the thesis, at least two articles should furthermore be accepted for publication in internationally recognised scientific magazines with referent review.

**Program management** The program is led by a programme co-ordinator together with a programme council consisting of 3-5 representatives from the central subareas of the subject, 2 doctoral student representatives and 2 external representatives. The programme council is responsible for the quality and development of the programme. The programme council convenes two-three times per year. All principal supervisors connected to the programme are included in the supervisor assembly of the programme. The supervisor assembly constitutes the academic arena for collegiate discussions of supervision issues, research quality, final reviews, doctoral students' progress, follow up on study plans, third-cycle courses and routines for follow up and evaluation.

**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) Research plan (within the first year), 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. Prior to the public defence of the doctoral thesis, the completed manuscript together with proposals for reviewer and examining committee should be presented to 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**
Today, the program has exchange with Universidade Nova de Lisboa, Karlsruhe Institute of Technology, University of Nottingham and Ecole Polytechnique Federale de Lausanne, among others. The international cooperations will be deepened and broadened.

The above is enumerated and defined in appendix 3.

**Further instructions for registration**

**Appendixes**

Appendix 1: Study plan for third-cycle subject Production Engineering (INDPROD).

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 — Production Engineering

Appendix 1: Study plan for third-cycle subject Production Engineering (INDPROD).

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

Subject title

Production Engineering (Industriell produktion)

Subject description and programme outcomes

Scientific field

The department of Production engineering runs education for first-cycle studies and education for second-cycle studies, research and education for third-cycle studies within the broad field production. The activities cover most central fields within the production design of today and manufacturing processes with close connections to the mechanical engineering industry. Study plan should be established with Production engineering as main subject, but initially with a possibility to specify a sub-field, "With specialisation in:"

- Production engineering metrology
- Adaptive production system
- Computer systems for design and production
- Machine and process technology

These specialisations are however not intended to be carried out as individual specialisations.

Description of possible specialisation

The subject has no specialisations.

Specification of how the programme outcomes are to be achieved

The aim of KTH's education for third-cycle studies is to provide the society with qualified researchers that can contribute to a sustainable development of the society. The goal of KTH's education for third-cycle studies is that the doctoral students should become independent, excellent researchers. The research (third-cycle) students should after completed studies be able to:
- describe and explain theories and empirical results within the current field
- formulate concrete research issues within the current field
- use scientific methods and provide new knowledge through own scientific studies
- critically analyse and evaluate applied methods and results from own and others'scientific studies
- present and discuss research results in the scientific community
- present research in an pedagogical way outside the science community and in educational situations
- assess ethical aspects of research within the current field and act from these and
- identify need for new knowledge and have knowledge of how to initiate and lead research

The education for third-cycle studies should also aim towards the doctoral student after completed studies being able to:

- participate in interdisciplinary cooperations within the current problem area and
- analyse the role of research in the development of the society

The principal supervisor together with the doctoral student should at follow up of the individual study plan state how the individual the doctoral student should be able to reach these aims. If the aims have not been satisfied at examination, the principal supervisor should be ready to explain why.

Current research

The research within the department is currently directed towards:
- System, technology and processes for material processing, part manufacturing and verification, and assembly
- Methods and aids for design, acquisition and development of production system
- Computer aids and information management for the cooperation in all parts of the product realisation process
- Product design for competitive production
- Industrial metrology
- Production economy Through the ongoing structure of the strategic research area XPRES- Excellence in production research- the subject area is extended with complementary scientific competence. The new fields are:
  - Production with use of new and future materials and methods
  - Product and production design, considering a life-cycle perspective
  - Adaptive and flexible production technology

Programme structure

The education for third-cycle studies are carry out under the guidance of a principal supervisor together with one or several assistant supervisors, in accordance with an individual study plan. The education consists of a course module and a thesis module and require an active participation in the activities at the department.

3.1 Supervision Each doctoral student works under the guidance of a principal supervisor together with one or several assistant supervisors. The principal supervisor should be professor, visiting professor or 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 doctoral degree and preferably belong to another subject area.

The primary supervisor is appointed by the director of third-cycle studies at the ITM school, after having been approved by the doctoral programme coordinator of the department. The doctoral students have the right to request a change of supervisor during their education.

3.2 Individual study plan Each doctoral student should have an individual study plan that has been approved by the doctoral programme coordinator of the department and the Director of third-cycle education at 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. Creating and updating 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 with the update 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 later 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 education office of the ITM school no later than 6 months after admission. The individual study plan should be updated at least once a year. An established/updated study plan should be registered in LADOK.

3.3 Departmental duties The education for third-cycle studies normally includes 20% departmental duties (counted over the whole doctoral study period), normally 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 educational ability will also be trained. Activities that may be part of the departmental duties include for example:

- Teaching/supervision/grading in courses that are given by the department
- Participation in course development
- Supervision of degree projects
- Work with web pages, information material, handling of computer tools, etc.

Each doctoral student should have participated at least once as teacher in one of the first or second cycle courses in Production engineering. For industry-based doctoral students, this is desirable, but no requirement.
The departmental duties are planned in collaboration with the principal supervisor and the department leaders 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. This also means that the departmental duties should if possible be planned, so that it is less duties during the final stage of the thesis.

3.4 Seminar participation In the third-cycle education, an active participation in the research seminars at the department is required, both at the department's 10 o'clock seminar series (4K5108) and the seminar series that are run by the different research teams (4K5203, 4K5304, 4K5202). The doctoral student should present his/her research at at least two occasions for Degree of Licentiate (study plan and final review) and at least three occasions for Degree of Doctor (study plan, intermediate/licentiate seminar and final review).

3.5 Final review Before the completion of the doctoral thesis, the doctoral student should present his/her manuscript at a final review seminar. The final review seminar is a part of the formal quality audit within the doctoral programme and aims at ensuring that the doctoral thesis is of sufficient scientific quality.

The final review seminar presents the second last version of the thesis manuscript, which implies that the thesis exists, if not in a complete version. The final review seminar should be carried out, so that there is time to revise the thesis and include comments, well in advance of the public defence of the doctoral thesis. The thesis should be reviewed by a reviewer, who has not previously been involved the doctoral student's thesis work. The reviewer should be docent.

3.6 Quality assurance before public defence of doctoral thesis The final thesis manuscript should be presented in writing by the principal supervisor for the supervisor assembly of the department, no later than 10 weeks before established date of the defence of the doctoral thesis. To the manuscript, written comments should be attached about changes that have taken place since the final review seminar. The supervisor assembly reviews that the thesis has been created according to established procedures and academic requirements and recommend it to be presented at a public defence of the doctoral thesis. In connection with this final audit, proposals for faculty opponent and examination committee are also discussed.

Compulsory and recommended courses

The education for third-cycle studies consists of a course module part and a thesis part:

- 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 major part of the courses is taken during the first years of the third-cycle studies. It can however also be relevant to acquire specialist knowledge later. It is important, that the course modules are described and explained in the individual study plan, related to the doctoral student's research specialisation.

By agreement with the principal supervisor, completed first and second cycle courses can be given credits in the individual study plan, for a maximum of 15 credits for Degree of Licentiate and no more than 25 credits for Degree of Doctor. Courses from first and second cycle may only be included if they treat fields that are relevant, and do not constitute entry requirements for the education for third-cycle studies.
Courses for third-cycle studies that are given at other higher education institutions of national doctoral schools and in international networks should be considered at the choice of courses.

All courses should approved by the doctoral student's principal supervisor and the programme co-ordinator for the doctoral programme.

4.1 **Compulsory courses** The following parts of the course compulsory:

- Literature study, Production systems (7.5 credits)
- State-of-the-art within Production research (7.5 credits)
- Production systems; 10 o'clock seminar (minimum 5 credits, at most 15 credits)
- The research process (7.5 credits)
- Scientific philosophy (7.5 credits)
- Higher seminar in Production engineering; 4K5202, 4K5303, 4K5105 (0.3 credits/per time, maximum 15 credits)

4.2 **Recommended courses**

There is a high grade of flexibility at determination of the courses that should be included in the education. For each doctoral student, the course modules should be planned together with the supervisors and be documented in the individual study plan so that the courses are related to the knowledge acquisition that is required for the research.

Courses in teaching and learning in higher education are a requirement, if teaching within first cycle and second cycle courses are to take place during the period of education.

Courses can, by agreement with principal supervisors, be included from previous education. At credit transfers, regulations in KTH's Degree Ordinance for third-cycle degrees should be observed.

4.3 **Optional courses**

- Scientific Writing, 5 credits
- Teaching and learning in higher education, 7.5 credits (compulsory for teaching doctoral students)
- Entrepreneurship and business development, 5 credits

4.4 **Conferences** Participation in conferences constitutes a central element in all education for third-cycle studies.

The conference participation must be planned in advance together with the principal supervisor.

4.5 **Other** It is common that research specialisation lead to knowledge acquisition in a field where there are no established courses. In such cases, it is possible to formulate a literature study course; such a course should be described with learning outcomes, delimitations, extent and plan for execution and it is normally presented in a report and at a seminar. Special literature study courses are established for this purpose.

**Thesis**

Thesis work is a compulsory part of the education for third-cycle studies, aiming at the doctoral student developing an ability to provide independent contributions to the research and the science community. The
thesis can either be written as a monograph or as a compilation thesis including scientific articles. 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).

5.1 **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 contributions 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 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 thesis is presented at a public seminar with an external reviewer/opponent.

5.2 **Doctoral thesis** A thesis for Degree of Doctor should contain new theoretical or empirical research results within the chosen subject area that the doctoral 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 contributions 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 referent review.

**Entry requirements and selection**

**General and special admission requirements and prior knowledge**

Qualified to be admitted to education for third-cycle studies in Production Engineering are:

- the one that has taken Master of Engineering or Degree of Master of Architecture, or
- the one that has taken other academic qualification for second-cycle studies (Master's degree 60 or 120 credits) or completed course requirements of at least 240 credits, of which at least 60 credits for second-cycle studies, that constitute good preparations for third-cycle studies within production engineering.
- under certain circumstances, exceptions from these requirements may be made, if equivalent knowledge can be considered have been acquired in a different way.

Doctoral student are expected to be able to read and write scientific English and be able to talk English fluently.

**Selection rules and procedures**
Admission to the education for third-cycle studies in Production engineering is determined by the dean of the ITM school, after review of entry requirements and suitability by the FA (Director of third-cycle education) of the ITM school, and acceptance from the programme co-ordinator of the doctoral programme.

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

**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 include 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 also the examiner, he/she must be docent and employed as teacher at KTH.

For Degree of Doctor, 240 credits are required, of which the course module should include 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 presented 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 members, appointed by the ITM school.

Theses can be written as a monograph or a compilation thesis. Normally, the thesis is written in English, but Swedish is also allowed.

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 earlier research within the chosen subject area. Whether the licentiate 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 two normal articles where the doctoral student is the primary author and that can be published in internationally recognised magazines/conferences with referent review.

A thesis for the Degree of Doctor should contain new theoretical or empirical research results within the chosen subject area that the student has developed via theoretical or empirical research. It should also contain an overview of earlier research within the chosen subject area. 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 normal articles where the doctoral student is the primary author and that can be published in internationally recognised magazines/conferences with referent review. Results and articles from a licentiate thesis can be reused in the doctoral thesis, provided that the quality requirements are satisfied.

For the thesis, a compilation thesis is primarily recommended. Publication during the education for third-cycle studies gives at best a possible modularisation and separate assessment of the parts of the thesis.
In KTH's internal regulatory framework the importance of continuous review of the research is emphasised.

To facilitate the research and improve the quality, the doctoral student should participate in national and international conferences within the knowledge field. It is recommended that possible publications are planned in the individual study plan. Regular publications give a possibility to interaction and feedback from other researchers and can facilitate the final thesis.

Compiled research material should all regularly be reviewed by the supervisor and should be presented via:
- scientific publications (with review process)
- presentations at conferences and for the industry
- seminars at the department

**The programme’s examinations**

A written examination should be included in courses for third-cycle studies. In certain cases, this can be substituted by an oral examination. 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 — Production Engineering

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

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