PROGRAMME SYLLABUS

Product Development, Product Development and Materials Engineering (master), 120 credits

Programme start: Autumn 2016
Title of qualification
Degree of Master of Science (120 credits) with a major in Product Development, specialisation in Product Development and Materials Engineering.

Programme overview
Background
As competition between companies is getting tougher as the number of products on the market increases, many are realizing the importance of product development and material knowledge as a competitive means. This programme covers the entire product development process, from conceptual engineering design to materials and manufacturing processes. The steady increase in the use of computer support makes possible new methods, which are parallel to the entire product development process. With the help of advanced computer tools in design, materials and construction, real and virtual prototypes can be produced much faster, and the time needed for development can be shortened. That is why engineers with advanced knowledge in this interdisciplinary field are needed.

Big and small businesses alike have an increasing need to integrate the steps of the product and production chain. This creates a need for engineers with specialist knowledge who at the same times have an insight in the whole product development process. Sweden has a world class engineering and automotive industry with a range of suppliers in the region of Jönköping. They are all in need of employees with knowledge of product, production and materials to stay competitive.

Objectives
This Master programme aims to develop the knowledge, skills and experience that are needed to develop and design advanced products with the use of modern information technology regarding knowledge-management and modeling. A further aim of the programe is to provide skills in achieving technological calculations to optimize product function, performance, material choice and manufacturing processes. The programme also aims to provide deepened knowledge concerning technical material's manufacturing, structural design, properties and use in products. The programme also serves as a preparation for research within the areas of product development, materials and manufacturing, and simulation and optimization.

Post-graduation employment areas
After completing the programme the graduate will be qualified for positions with companies in need of a modern product development process using efficient tools. The programme also qualify for working in research in e.g. design, materials and production processes as well as in computer simulation of products.
Programme Supportive Research
In close cooperation with the programme, research carried out in the fields of Product development (specializing in Computer Supported Engineering Design and Simulation and Optimization) and Materials and Manufacturing specializing in Casting.

Product development focused on computer supported engineering design

Computer Supported Engineering Design
 Implemented knowledge as a competitive factor in the manufacturing industry
Success in manufacturing companies is always based on deep knowledge of the product characteristics and the production processes used. This knowledge is stored in the minds of employees, written down in documents or implicit in proprietary computer codes. This is a knowledge structure that is often the company’s most important asset. Using modern information technology, this knowledge can be structured and stored for later retrieval and automated reuse for new development projects.

Computer tools for automated engineering design
Functions for storage of knowledge and inferring conclusions from this are fundamental for design systems aimed at design synthesis tasks. The possibilities to create such systems for automated design have improved dramatically. The technology of Artificial Intelligence has provided rule-based programming tools as well as more implicit methods in the category of “computational intelligence”. In combination with parametric CAD systems these techniques are suitable to capture experience, rules of thumb as well as algorithmic design rules. Within this technical domain we try to establish generic guidelines for how Intelligent Design systems should be composed to match different design tasks. How cost and benefit should be balanced in different applications and how length of operational life, transparency and quality of these systems is assured. We seek to penetrate the potential and constraints of the technology in a systematic fashion so that companies who intend to carry out industrial applications can find optimal solutions. Since we always work with real industrial examples the technological contents naturally cover a wide spectrum.

Simulation and Optimization
The field of simulation has over the last 20-30 years had a tremendous development, especially the non-linear finite element method (FEM). Virtual experiments have been made possible by programming basic principles of nature into computers, e.g. simulations of crashworthiness and sheet metal forming. These kinds of virtual tests reduce both costs and lead times, and create better products for the consumers.

The development has come so far that non-linear finite element analysis (FEA) is becoming an industry standard also for small- and medium-sized companies. Simulation driven design reduces both costs and lead times by reducing the number of physical prototypes and experiments. This virtual development process can also be automated by combining FEA with optimization methods. We call such an automated design process for Optimization Driven Design (ODD). The introduction of ODD is the next big step for large companies and will also be important to take for small- and medium-sized companies in a near future. In particular our research is focused on non-linear FEA, topology optimization and surrogate optimization for both deterministic and non-deterministic problems.

Materials and manufacturing focused on casting
The research within Materials and manufacturing is multidisciplinary and could comprise research areas such as product development, properties of components, internal material structures and related properties of components, production/manufacturing aspects etc. The research has support within a wide spectrum of subject areas: e.g. fluid dynamics, solid mechanics, material science, material technology, material physics, chemistry, as well as simulation and optimization. In the product development chain, the main part of the research is conducted in the interface between engineering design on one side and manufacturing/usage aspects on the other, with a special focus on product properties. The overall goal of the operation is to conduct fundamental research with the purpose of solving problems related to material science and manufacturing of advanced cast metal components, in close cooperation with
industry and research institutes. The different steps in the product development process, from conceptual design to material selection and manufacturing method, all have a decisive influence on the final properties of the component. This is especially true for metal casting and for shaping of polymers. As a consequence, it is natural that simulation and optimization tools/methodologies today are indispensable when designing and manufacturing complex shaped components of advanced materials.

**Educational concept at the School of Engineering**

All educational training at the School of Engineering in Jönköping (JTH), is determined by an educational concept. The concept offers a holistic perspective, where Business Community Contacts, Internationalisation and Entrepreneurial Drive are key words. Besides technical knowledge within the programme, Leadership and Communication, Professional Attitude and Sustainable Development are important parts of the concept.

**Business Community Contacts** means that JTH has an established collaboration with the business community in various forms throughout the training. An example is the course located directly in the business community (*Industrial Placement Course*), which is part of all programmes. The aim with this course is to provide the students with an understanding for future professional tasks, and the ability to relate these to the training.

**Internationalisation** means that students e.g. are given the opportunity to train languages and intercultural communication through exchanges with foreign universities. JTH has approximately 70 partner universities all over the world, and participates in several international exchange programmes for students. There are opportunities to spend parts of the training abroad and account to the foreign credits in the exam. Due to this student exchange, a great number of courses at JTH are given in English.

**Entrepreneurial Drive** is received through the holistic perspective of the training programme. Significant is the exchange with the business community, the leadership training, the association with professional work in project based courses, and the economy elements, among other things.

**Leadership and Communication** includes e.g. training in verbal and written communication, project based work, leading and motivating people and also to understand decision processes in companies and organizations.

**Professional Attitude** comes through basic knowledges in economics, marketing, and business planning. These knowledges are further developed and integrated in technical contexts. Engineers and technicians with such experiences are useful within a great number of areas in the business community.

**Sustainable Development** includes understanding of compatibility with a sustainable society and environmental and human aspects in the future productivity and products. The instructions are fully integrated in their technical context and treat social, economical and ecological aspects of sustainable development.

**Project based Training** is also a part of the educational concept. Assuming responsibility for projects of various sizes frequently occurs as a professional. As a preparatory step, the students are responsible for real projects in connection with the business community in some of the courses.

**Student influence** is a great and important part in JTH’s continuous quality development. Through student representatives in all boards, councils and decision-making committees, the students actively influence their education.

**Objectives**

After the completion of the programme, students must meet the intended learning outcomes, as described in the Ordinance by Higher Education (m), and also the intended learning outcomes, as described by JTH (j):

**Common learning outcomes**

**Knowledge and Understanding**

1. demonstrate knowledge and understanding in their main field of study, including both broad
knowledge in the field and substantially deeper knowledge of certain parts of the field, together
with deeper insight into current research and development work; and,(m)
2. demonstrate deeper methodological knowledge in their main field of study.(m)

Skills and Abilities
3. demonstrate an ability to critically and systematically integrate knowledge and to analyse,
assess and deal with complex phenomena, issues and situations, even when limited information
is available,(m)
4. demonstrate an ability to critically, independently and creatively identify and formulate issues
and to plan and, using appropriate methods, carry out advanced tasks within specified time
limits, so as to contribute to the development of knowledge and to evaluate this work,(m)
5. demonstrate an ability to clearly present and discuss their conclusions and the knowledge and
arguments behind them, in dialogue with different groups, orally and in writing, in national and
international contexts; and,(m)
6. demonstrate the skill required to participate in research and development work or to work
independently in other advanced contexts.(m)
7. prove ability to independently apply acquired knowledge in practical work, and insights in
future professional positions.(j)

Judgement and Approach
8. demonstrate an ability to make assessments in their main field of study, taking into account
relevant scientific, social and ethical aspects, and demonstrate an awareness of ethical aspects of
research and development work;(m)
9. demonstrate insight into the potential and limitations of science, its role in society and
people's responsibility for how it is used; and(m)
10. demonstrate an ability to identify their need of further knowledge and to take re-sponsibility
for developing their knowledge.(m)
11. prove insights in the professional engineering role and responsibility in the society, assuming
human conditions and needs and the goals for economical, social and ecological sustainable
development in the society,(j)
12. prove immersed ability to interdisciplinary manners and to apply a system perspective.(j)

Programme-specific learning outcomes
The intended learning outcomes provided for programmes, must also be met.

Knowledge and Understanding
13. display knowledge of the general properties of metals, polymers and ceramics as well as being
able to make a connection to the structure of atoms and the microscopic level.
14. display knowledge of how different manufacturing processes, with particular focus on
casting, affects the structure of materials and, in turn, the product's properties.

Skills and Abilities
15. demonstrate ability to independently use advanced calculation programmes, construction
tools and methods to model, analyse and optimise different technical problems regarding
functions, performance, material choice and costs.
16. demonstrate ability to employ a structured and effective process for the development of new
products as well as for product care, and being able to understand and govern the use of modern
computer based methods for this work.

Contents

Programme Principles
The programme consists of a number of courses that will advance the students' knowledge in
Product development, Materials and manufacturing, and Simulation and optimization. These
three fields reflects the scientific research being conducted at JTH.
All courses within the program are given in English.

Year 1
The programme starts with an introductory course aimed at providing a shared view on what is
meant by industrial product realisation including the methodology and leadership. The courses
within product development: Integrated Product Development and Computer Programming for Design Automation address how the development of products is conducted and can be supported.

In the courses Materials and Design and Functional Materials and Surfaces the selection of materials and surface coating of materials are elaborated.

The students also advance their knowledge in design analysis and optimisation of products in various stages of the product development process. In the courses Non-linear FEA and Optimisation Driven Design moderns analysis tools are used for this purpose. The understanding of the theory behind the tools is also extensively elaborated.

Year 2

The advancement within Product development, Materials and manufacturing, and Simulation and optimization continue in year 2 in the courses Advanced Materials Technology, Computer Supported Engineering Design, and Modelling and Simulation of Casting. By the start of the third semester the students are prepared to do an internship off campus to try their future role as experts in the course Off Campus Integrated Theory and Practice in Product Development. This involve practicing the knowledge gained earlier in the programme. The second semester year 2 is spent on a final project in which a research or development project based on a relevant issue is conducted and reported in a scientific way.

Programme progression

The courses within the three fields run in parallel throughout the whole programme, resulting in a broad knowledge within industrial product realisation. Within each field there is a progressive deepening, the introductory courses have a more basic character, followed by an increased degree of difficulty. The latter courses are more focused on a deep knowledge about the theory behind, and the practical use of computer based methods and simulation in product development. The final courses are also closer to the current research. Different project works are included in the education, these are supposed to train the students to work more independently, and with a scientific attitude, and also provide an opportunity to apply the knowledge to real problems. This creates the platform used as a basis for the final thesis project, where the student accomplishes a research or development project based on a relevant problem.

Courses

Mandatory courses

<table>
<thead>
<tr>
<th>Course Name</th>
<th>Credits</th>
<th>Main field of study</th>
<th>Specialised in</th>
<th>Course Code</th>
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<tbody>
<tr>
<td>Advanced Materials Technology</td>
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<td>Product Development</td>
<td>A1N</td>
<td>TAMR27</td>
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<td>Computer Supported Engineering Design</td>
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<td>Product Development</td>
<td>A1F</td>
<td>TDKS27</td>
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<td>Final Project Work in Product Development</td>
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<td>Product Development</td>
<td>A2E</td>
<td>TEUV24</td>
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<tr>
<td>Functional Materials and Surfaces</td>
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<td>A1F</td>
<td>TFYS27</td>
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<td>TIPS25</td>
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<td>Product Development</td>
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<td>TMDR26</td>
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<tr>
<td>Modelling and Simulation of Casting</td>
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Elective courses

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<th>Course Name</th>
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<tr>
<td>Non-linear Finite Element Analysis</td>
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<td>Optimization Driven Design</td>
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<td>TODS27</td>
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<td>Computer Programming for Design Automation</td>
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<td>Product Development</td>
<td>A1N</td>
<td>TPAR27</td>
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Programme overview

Year 1

<table>
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<tr>
<th>Semester 1</th>
<th>Semester 2</th>
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<tbody>
<tr>
<td><strong>Period 1</strong></td>
<td><strong>Period 2</strong></td>
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<td>Industrial Product Realization, Process Methods, Leadership, 9 credits,</td>
<td>Materials and Design, 6 credits</td>
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<tr>
<td>Materials and Design, 6 credits</td>
<td>Functional Materials and Surfaces, 6 credits</td>
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<tr>
<td>Advanced CAD $^1$, 6 credits</td>
<td>Computer Programming for Design Automation, 6 credits</td>
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<tr>
<td>Multivariable Calculus $^1$, 6 credits</td>
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Year 2

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<th>Semester 3</th>
<th>Semester 4</th>
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<tr>
<td><strong>Period 1</strong></td>
<td><strong>Period 2</strong></td>
</tr>
<tr>
<td>Advanced Materials Technology, 6 credits</td>
<td>Computer Supported Engineering Design, 9 credits</td>
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<tr>
<td>Industrial Placement Course in Product Development, 9 credits</td>
<td>Final Project Work in Product Development, 30 credits</td>
</tr>
<tr>
<td>Modelling and Simulation of Casting, 6 credits</td>
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Teaching and examination

Academic year is divided into two semesters and normally read two courses in parallel. Examination forms and grades are given by each course plan, respectively. The programme overview shows the programme structure for both years and may be changed during the programme. For updated programme overview see http://www.jth.hj.se

Prerequisites

The applicant must hold the minimum of a bachelor’s degree (i.e. the equivalent of 180 ECTS credits at an accredited university) with at least 90 ECTS credits in mechanical engineering, or equivalent. The bachelor’s degree should comprise a minimum of 21 ECTS credits in mathematics. English proficiency is required.

Continuation Requirements

In order to begin the second year, at least 30 credits from the programme's first year must be completed.

Qualification Requirements

To obtain a Degree of Master of Science in Product Development, specialisation in Product Development and Materials Engineering, students must complete a minimum of 120 higher education credits in accordance with the current programme syllabus, at least 60 of which must be in the main field of study Product Development and 21 credits in Mathematics.
In addition a Degree of Bachelor of Science in Engineering/Degree of Bachelor of Science or an equivalent Swedish or foreign qualification is required.

Quality Development
Management councils, Head of Programmes, teachers and students work together with the development of the programmes and courses. All students get the opportunity to do a course evaluation after each completed course and before graduation time. The results of the evaluation are presented to the Head of Programmes, Head of Departments, Course Coordinators and to the Director of Education for further development.
Head of Departments, or corresponding, and Head of Programmes raise questions regarding the programme development within the Council of Programmes.
Student representatives, Director of Education and Study Counselor meet four times per year to discuss the recent completed courses within the programmes.
The chairman of students Educational Committee is a regular member in Council of Education.

Other Information
Course included in the programme can be read as a separate course, subject to availability. Prerequisites are stated in the syllabus.
Non-EU/EEA/Switzerland citizens pay tuition fees at the current rate. For further information see http://www.hj.se, / / Tuition and Application Fee / /