JÖNKÖPING UNIVERSITY
School of Engineering

PROGRAMME SYLLABUS

# Materials and Manufacturing (master), 120 credits

*Materials and Manufacturing (master), 120 högskolepoäng*

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|---|---|---|---|
| Programme Code: | TAMM5 | Programmestart: | Autumn 2025 |
| Confirmed: | Feb 01, 2025 | Education Cycle: | Second-cycle level |

## Title of qualification

Degree of Master of Science (120 credits) with a major in Product Development specialisation in Materials and Manufacturing

Teknologie Masterexamen med huvudområdet Produktutveckling inriktning Material och tillverkning

## Programme overview

### Main field of study

Product development includes the study of products as technical systems and the business process of activities that from identified needs and/or technological advancements, develop, define, validate, and over time improve a product, including its associated services. Product development is built on technical knowledge and systematic methods combined with creative processes. Product development requires multi-disciplinary collaboration between e.g. mechanical engineering, design, materials, information technology, electronics, construction, production and industrial economics. The application of simulation and management of development activities are also important.

Product development combines a technical perspective, with a scientific basis in mathematics and physics, with a context of humanistic and social science, in which business and sustainability aspects are important areas for the subject. Methods for research includes, among others, empirical studies, modelling, case studies, action research and constructive methods. The studies are based on knowledge in an application area of mechanical engineering, design, materials, information technology, electronics and construction, individually or in combination.

Studies in product development fosters knowledge in the application area, see above, in combination with knowledge of products as technical systems in combination with systematic and creative development methods as well as methods for simulation and management of development activities. Knowledge in different fields, such as industrial economics, ergonomics, aesthetics, quality, socio-technical systems are in parts complementary subjects for studies in product development. Skills that are developed include ability to analyse needs, establish requirements specification, development of functional description and system structure, generate alternative solutions, designing individual subsystems, analysing the characteristics and requirements fulfilment, as well as perform system integration and validation. Ability work interdisciplinary and in a development organisation is important as well as the application of a holistic perspective on the different phases of the product life cycle and its various stakeholders.

### Background

Materials and manufacturing have had a critical role across various industries, including aerospace, automotive, electronics, biomedical, and energy. Nowadays, due to the increased need for advanced materials which have improved performance, sustainability, and efficiency, Materials and Manufacturing technologies have become even more influential in industries, and the demand for skilled professionals in this domain has grown drastically. By studying Materials and Manufacturing, students will gain knowledge of the relationship between the structure and properties of materials, which is critical for designing and optimizing materials for specific applications. In addition, learning manufacturing technologies provides a comprehensive understanding of how a component can be produced and how different manufacturing technologies influence the final characteristic of the component. By combining traditional and modern technologies as well as simulation, the creation of complex geometries and customized products with better

sustainability can be achieved. Materials and manufacturing give the required knowledge to engineers who can influence society and industry to become more sustainable.

This programme gives a general understanding of the theories behind materials (metals and alloys, polymer and composite materials), their manufacturing processes and their role in the entire product development process during the first year. Then, in the second year, it provides a unique opportunity for the students to have an industrial placement course or a project course to be skilled for their career both in industry and academia.

### Objectives

### The goal of this programme is to:

- Provide the required knowledge in materials science principles and manufacturing technologies
- Equip students with the skills to select appropriate materials and manufacturing technology for various applications
- Enable students to design a product by considering required performance, geometry and sustainability aspects

The above-mentioned goals provide the necessary skills for the students to contribute to the industry's competitiveness through cutting-edge expertise, innovation and commitment to global sustainability.

### Post-graduation employment areas

Graduates of this programme will be well-prepared for diverse roles in research and development, quality control, production management, and engineering consulting. They will find opportunities in different sectors such as aerospace and defence, automotive and transportation, biomedical and healthcare and so on.

## Objectives

### Common learning outcomes

After the completion of the programme, students must meet the intended learning outcomes, as described in The Higher Education Ordinance by Degree of Master, and also the intended learning outcomes, as described by JTH:

### Knowledge and Understanding

1. demonstrate knowledge and understanding in the main field of study, including both broad knowledge of the field and a considerable degree of specialised knowledge in certain areas of the field as well as insight into current research and development work
2. demonstrate specialised methodological knowledge in the main field of study

### Competence and skills

3. demonstrate the ability to critically and systematically integrate knowledge and analyse, assess and deal with complex phenomena, issues and situations even with limited information
4. demonstrate the ability to identify and formulate issues critically, autonomously and creatively as well as to plan and, using appropriate methods, undertake advanced tasks within predetermined time frames and so contribute to the formation of knowledge as well as the ability to evaluate this work
5. demonstrate the ability in speech and writing both nationally and internationally to clearly report and discuss his or her conclusions and the knowledge and arguments on which they are based in dialogue with different audiences
6. demonstrate the skills required for participation in research and development work or autonomous employment in some other qualified capacity

### Judgement and Approach

7. demonstrate the ability to make assessments in the main field of study informed by relevant disciplinary, social and ethical issues and also to demonstrate awareness of ethical aspects of research and development work
8. demonstrate insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used
9. demonstrate the ability to identify the personal need for further knowledge and take responsibility for his or her ongoing learning

JTH. prove ability to embrace interdisciplinary approaches

### Programme-specific learning outcomes

Upon completion of the programme, the intended learning outcomes provided for programme must also be met.

### Knowledge and Understanding

10. demonstrate a comprehensive understanding of the general properties of various material types and

establish connections between these properties and their atomic structure and microstructure.
11. exhibit knowledge of how different manufacturing processes influence the structure of materials, thereby affecting product properties, along with an understanding of how to control and manage these processes effectively.
12. demonstrate knowledge of the sustainability aspects associated with various materials and manufacturing technologies.

Competence and skills

13. demonstrate the ability to independently utilize computational software, design tools, and methods to model, analyze, and optimize various technical problems related to functionality, performance, material selection, and cost.
14. demonstrate the ability to conduct independent research or project work
15. demonstrating the ability to innovate within the field of materials and manufacturing

Judgement and Approach

16. demonstrate the ability to critically evaluate the selection of materials and processes for the development of engineering components, considering functional, financial, and environmental requirements.
17.demonstrate the ability to approach engineering problems with a holistic perspective, considering the interplay between materials, design, manufacturing methods, and environmental impacts to devise sustainable and effective solutions.
18.demonstrate the ability to collaborate effectively within interdisciplinary teams, applying engineering principles to solve complex problems in materials and manufacturing.

## Contents

Programme principles

The master Programme in Materials and Manufacturing is a two-year curriculum divided into four semesters, with each semester consisting of two periods. Courses are typically 7.5 credits, while a project course or an industrial placement course is 15 credits. The thesis work is 30 credits.

Year 1:

In the first year, students will complete a total of eight mandatory courses. All courses during the first year are mandatory courses of 7.5 credits each. Two courses always run in parallel for half a semester (one period). Below is a brief overview of the mandatory courses:

*Semester 1:*

- Polymer and Composites technology
  Covers polymers, polymer-based composites, and their manufacturing aspects
- Chemical Thermodynamics
  Provides foundational knowledge essential for understanding phase transformations, along with computational thermodynamics
- Liquid Metal and Solidification Processing
  Focuses on sustainable management of circular materials. The fundamental mechanisms of solidification and different conditions to control microstructure will be discussed.
- Metallic Materials: From Phase Transformation to Characterization
  Focuses on phase transformations in metals and alloys and characterization techniques for material properties.

*Semester 2:*

- Materials and Process Selection for Product Design
  Introduces the guidelines to select materials and processes according to the function of components and sustainability aspect
- Surface Technology
  Introduces fundamental concepts in surface engineering, emphasizing the importance of surface characteristics for the final product
- Sustainable Product Realization
  Covers life cycle assessment of products
- Manufacturing Process Simulation
  Focuses on how to use powerful simulation tools to optimize manufacturing processes and create sustainable, high-quality products

Year 2:

*Semester 1:*
In the first semester, students will have two mandatory courses each 7.5 credits, as follows.

- Research Methodology on Advanced Level
  The course gives insight into the foundations of science and covers various research approaches. The course is preparatory for conducting the thesis work and for authoring the thesis.
- Application of Computational Fluid Dynamic and Heat Transfer
  Introduces fundamentals of computational fluid dynamics and heat transfer, and methodologies for solving a broad range of multi-disciplinary engineering problems in the context of manufacturing process and component design

In parallel with the mandatory courses, students can choose between IPC and Project courses to prepare their thesis for the next semester.

*Semester 2:*
The last semester is dedicated to the master thesis.

### Research basis

The main research in this programme is focused on the following aspects:

- Sustainable Material Development

Alloy Development: Focus on designing and optimizing new sustainable alloys that reduce reliance on rare or toxic elements while enhancing mechanical properties.

- Advanced Manufacturing Processes

Casting Technologies: Research innovative casting methods that improve material performance and reduce energy usage.
Post-Processing Techniques: Develop and optimize coating and anodizing processes that enhance corrosion resistance and wear resistance while minimizing environmental impact.

- Mechanical Property Optimization

Microstructure Engineering: Explore how variations in processing parameters and materials composition affect the microstructure of materials, leading to improved mechanical properties and performance.
Testing and Simulation: Utilize advanced computational methods and simulations to predict material behavior under different conditions, enabling the design of superior materials.

- Sustainability Metrics and Assessment

Environmental Impact Analysis: Establish metrics to evaluate the environmental impact of materials and processes, focusing on energy consumption, waste generation, and lifecycle emissions.

The research basis in this programme is closely connected to industry and real application and emphasizes a holistic approach to developing sustainable materials and manufacturing technologies. By focusing on alloy innovation, advanced processing methods, and sustainability metrics, the programme aims to not only enhance material properties but also contribute to a more sustainable manufacturing ecosystem. This approach prepares graduates to lead the creation of environmentally responsible solutions in the materials and manufacturing sectors.

### Equal terms, gender equality and diversity

The School of Engineering (JTH) strives in all its activities to ensure that all individuals are given equal opportunities and treated equally. At both the JU and JTH levels, this is reflected in governing documents concerning organizational and personnel matters, the establishment and delivery of programmes and courses, as well as the monitoring of educational quality. At JTH, student influence is also ensured through student representation in various educational and industry councils.

Our master's programme in Materials and Manufacturing is committed to fostering an inclusive and equitable academic environment where individuals from all backgrounds have equal opportunities. We actively promote gender equality by encouraging the participation of individuals of all genders in our programme, ensuring that everyone has access to the same opportunities, resources, and support.

The subject of materials and manufacturing is not related to any gender but to an object. In addition, the personal activity and study environment at the Materials and Manufacturing department is functional for both men and women. Moreover, hands-on projects and facilities are for all genders, sizes, and heights to create a functional environment. An Exchange room for both genders is provided as well.

### Study abroad

The School of Engineering has internationalization as a focus area where the educational programmes include opportunities for both international experiences at home as well as various opportunities to do internships and study abroad, giving students valuable experiences and skills to prepare them for a global labour market.

The third semester provides the opportunity for studying abroad.

### Programme progression

The master programme in Materials and Manufacturing is designed to equip students with the skills needed to select, analyze, and develop sustainable materials and manufacturing processes. This programme delves into the crucial connections between material properties, manufacturing technologies, and the resulting characteristics of products, focusing on both metals and polymers.

A foundational course in thermodynamics introduces key concepts in physical metallurgy, enabling students to grasp solidification phenomena and phase transformations that are essential for effective material design. The course on liquid metal and solidification processes, which focuses on casting—one of the most significant manufacturing technologies—highlights strategies to enhance sustainability within these processes. In the metallic materials course, students gain comprehensive knowledge on engineering microstructures to achieve specific material properties and learn effective characterization methods. Integrating insights from both polymer and metallic materials studies, the course on materials and process selection for product design guides students in choosing appropriate materials and manufacturing processes based on performance requirements and sustainability considerations.

Students also engage in advanced surface technology, where they learn to optimize surface finishes and component properties, applying knowledge from previous courses on metallic materials and thermodynamics in practical scenarios. The manufacturing process simulation course allows students to synthesize their first-year knowledge, emphasizing the significance of selecting manufacturing processes through simulation techniques, which are further supported by studies in Computational Fluid Dynamics and Heat Transfer.

As a culmination of their studies, the sustainable product realization course teaches students to design products that integrate considerations of materials, manufacturing, design, sustainability, and life cycle assessment, ensuring a holistic approach to product development.

## Courses

Course changes can occur, as long as they do not substantially affect the programme's content and learning goals.

### Mandatory courses

| Semester | Course Name | Credits | Main field of study | Specialised in | Course Code |
|---|---|---|---|---|---|
| 1 | Chemical Thermodynamics | 7.5 | | A1N | TCHR21 |
| 1 | Metallic Materials: from Phase Transformation to Characterization | 7.5 | Product Development | A1F | TMMS25 |
| 1 | Polymer and Composite Technology | 7.5 | Product Development | A1N | TPKR25 |
| 1 | Liquid Metal and Solidification Processing | 7.5 | Product Development | A1F | TSPS25 |
| 2 | Sustainable Product Realisation | 7.5 | Product Development | A1F | THFS25 |
| 2 | Materials and Process Selection in Performance Design | 7.5 | Product Development | A1N | TMPR25 |
| 2 | Manufacturing Process Simulations | 7.5 | Product Development | A1F | TTPS22 |
| 2 | Surface Technology | 7.5 | Product Development | A1F | TYTS22 |
| 3 | Possibility to study abroad | 30 | | | |
| 3 | Research Methodology on Advanced Level | 7.5 | Product Development, Production Systems | A1N | T2FPAN |
| 3 | Applications of Computational Fluid Dynamics and Heat Transfer | 7.5 | Product Development | A1F | TTBS22 |
| 4 | Final Project Work in Product Development | 30 | Product Development | A2E | TETT23 |

### Elective courses

| Semester | Course Name | Credits | Main field of study | Specialised in | Course Code |
|---|---|---|---|---|---|
| 3 | Industrial Placement Course - Research Track | 15 | Product Development | A1F | TNSS25 |
| 3 | Project Course | 15 | Product Development, Production Systems | A1N | TPJS22 |

## Teaching and examination

The academic year is divided into two semesters, and the semesters into two study periods. In each study period two courses are generally taken in parallel. Assessment is part of each course or module. Modes of assessment and grades are shown in each course syllabus.

## Entry requirements

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 credits in materials and manufacturing, materials engineering, mechanical engineering, chemical engineering, product development or engineering physics or equivalent. The bachelor’s degree should comprise a minimum of 15 credits in mathematics. Proof of English proficiency is required.

## Continuation Requirements

In order to begin the second year, at least 37,5 credits from the programme's first year must be completed.

## Qualification Requirements

To obtain a Degree of Master of Science (120 credits) with a major in Product Development, specialisation in Materials and Manufacturing, students must complete a minimum of 120 credits in accordance with the current programme syllabus 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

At JTH, systematic quality assurance is carried out within JU's established quality system. This system, based on the requirements of the Higher Education Act, the Higher Education Ordinance, and the Standards and Guidelines for Quality Assurance in the European Higher Education Area, has been reviewed and approved by the Swedish Higher Education Authority.

Active and continuous course evaluation, including student feedback through course surveys, forms one of the cornerstones of this system. Annual programme evaluations and student representation in JTH's various educational and industry councils are two additional examples.

## Other Information

Admission is under ‘Admission regulations for first- and second cycle courses and study programmes at Jönköping University (Admission regulations)’.

This syllabus is based on ‘Regulations and guidelines for first-, second- and third-cycle education at Jönköping University’.