



# Curriculum for The Bachelor's Program in Manufacturing and Operations Engineering

Aalborg University  
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**Preface**

Pursuant to Act 367 of March 25, 2013 on Universities (the University Act) with subsequent changes, the following curriculum for the Bachelor's program in Manufacturing and Operations Engineering is established. The program also follows the Framework Provisions and the Examination Policies and Procedures for the Faculty of Engineering and Science.

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## **Chapter 1: Legal Basis of the Curriculum, etc.**

### **1.1 Basis in ministerial orders**

The Bachelor's program in Innovative Production Development is organized in accordance with the Ministry of Science, Technology and Innovation's Ministerial Order no. 1520 of December 19, 2013 on Bachelor's and Master's Programs at Universities (the Ministerial Order of the Study Programs) and Ministerial Order no. 1518 of December 19, 2013 on University Examinations (the Examination Order) with subsequent changes. Further reference is made to Ministerial Order no. 1487 of December 16, 2013, (the Bachelor Programme Admission Order) and Ministerial Order no. 250 of March 15, 2007 (the Grading Scale Order) with subsequent changes.

### **1.2 Faculty affiliation**

The Bachelor's program falls under the Faculty of Engineering and Science, Aalborg University.

### **1.3 Study Board affiliation**

The Master programme falls under the Board of Studies for Industry and Global Business Development under the School of Engineering and Science.

## **Chapter 2: Admission, Degree Designation, Program Duration and Competence Profile**

### **2.1 Admission**

Admission to the Bachelor's program in Manufacturing and Operations Engineering requires an upper secondary education.

The program's specific entry requirements are:

- English B *or* an acceptable IELTS
- Mathematics A
- Physics B and Chemistry C - *or* Physics B and Biotechnology A – *or* Earth science A og Chemistry C.

cf. the Admission Order.

The University can stipulate requirements concerning conducting additional exams prior to the start of study. The study board may limit admission or cancel the education or specific courses if the number of admitted students is too low.

### **2.2 Degree designation in Danish and English**

The Bachelor's program entitles the graduate to the designation:

Bachelor (BSc) I teknisk videnskab (produktionsudvikling).

The English designation is:

Bachelor of Science (BSc) in Engineering (Manufacturing and Operations Engineering).

### **2.3 The program's specification in ECTS credits**

The Bachelor's program is a 3-year, research-based, full-time study program. The program is set to 180 ECTS credits.

### **2.4 Competence profile on the diploma**

The following will appear on the diploma:

- A graduate of the Bachelor's program has competencies acquired through an educational program that has taken place in a research environment.
- A graduate of the Bachelor's program has fundamental knowledge of and insight into his/her subject's methods and scientific foundation. These properties qualify the graduate of the Bachelor's program for further education in a relevant Master's program as well as for employment on the basis of the educational program.

### **2.5 Competence profile of the program**

Persons obtaining Bachelor's degrees:

#### *Knowledge*

- possess knowledge about theories, methodologies and practice in the areas of innovation technology, systems, processes, manufacturing, production and service.
- are able to understand and reflect on theories, methodologies and practice within these subject areas
- have knowledge in design and planning processes in relation to innovative production development.
- know about the important connection between a) business models, b) products and services, c) product and service innovation, d) productions systems, e) operations

management and f) the actors and technologies involved in the productions and development processes.

### *Skills*

- are able to apply selected methodologies and tools provided by the available innovation technologies
- are able to analyze and evaluate theoretical and practical issues within innovative production development in a broader socio-economic context
- are able to develop and implement services and applications using innovation technology related skills
- are able to develop new and improve existing innovation technologies.
- are able to explain the reasons for and choose relevant solution models for technology improvement and for technology applications
- are able to communicate academic, technical and related business issues and solution models to peers and non-specialists or collaboration partners and users from an interdisciplinary perspective

### *Competencies*

- are able to handle complex and development-oriented situations in study or work contexts
- are able to solve problems using mathematical and technological tools
- are able to combine technological, economic and social/policy perspectives to analyze and contribute to the operation and development of innovative production and service systems
- are able to independently participate in discipline-specific and interdisciplinary cooperation with a professional approach
- are able to identify their own learning needs and organize their own learning in different learning environments
- are able to oversee the entire process from the innovation to the production and service in terms of innovation technologies and production systems,
- are able to communicate with end-users, both non-professional and professional users such as designers and engineers
- are able to identify how to employ innovation technologies to facilitate, improve and integrate product, service and production development processes



### Chapter 3: Content and Organization of the Program

Innovation technologies facilitate and support the innovation process of new products, services and processes as well as their production and manufacturing.

Innovation technology allows organizations to simulate and virtualize products, services and production, supports their development, allows rapid prototyping and reduces the time from the design and development phase to the actual manufacturing. Virtualization, rapid prototyping and social media offer early end-user involvement which increases the idea potential and reduces uncertainty in the innovation process, and virtualized products, crowd-sourcing and data-mining effectively reduce the time to market.

The overall aim of the program is to educate and equip bachelor engineers with innovation technology and understanding of state-of-art production technology and systems. The students will become a technology facilitators and developers as well as users. This is done by providing the students with a solid understanding of a) innovation technologies and b) production technology and systems within manufacturing, and the increased layer of servitization associated with the physical product. The education supports a broad definition of service (a non-physical product) that includes both public and private service processes and that includes the material side of service such as information storage, computer infrastructure, machine intelligence and e-commerce..

In addition to the technological aspects, this bachelor education will equip the students with the skills and competences to a) oversee the entire process from the innovation to the production and service in terms of innovation technologies and production systems, b) communicate with end-users, both non-professional and professional users such as designers and engineers and c) to identify how to employ innovation technologies to facilitate, improve and integrate product, service and production development processes. The program strives to give the students a comprehensive understanding of the important connection between a) business models, b) products and services, c) product and service innovation, d) productions systems, e) operations management and f) the actors and technologies involved in the productions and development processes.

The program is structured in modules and organized as a problem-based study. A module is a program element or a group of program elements, which aims to give students a set of professional skills within a fixed time frame specified in ECTS credits, and concluding with one or more examinations within specific exam periods. The examinations are defined in the curriculum.

The program suggests two tracks: **Track A** focuses on production and production technology, and provides the necessary background knowledge on services. **Track B** focuses on production and services, and provides the necessary background knowledge on production technology. However, the student is free to choose courses from either track.

All projects are to be conducted in English. The study board may, in some cases, exempt from this.

The program is based on a combination of academic, problem-oriented and interdisciplinary approaches and organized based on the following work and evaluation methods that combine skills and reflection:

- lectures
- classroom instruction
- project work
- workshops
- exercises (individually and in groups)
- project work, simulation and exercises in labs
- teacher feedback
- reflection
- portfolio work

The BSc education in innovative production development is taught in English. All activities, including the above stated, are carried out in English. All exercise work and deliverables, project-work (as well as any documentation in connection to these) delivered by the student must be written in English and all exams are carried out in English. In accordance with the current Framework Provisions, The Study Board for Industry and Global Business Development may choose to exempt from this rule in extraordinary cases, which in principle requires a well-documented application from the student and/or teacher.

### 3.1 Overview of the program

All modules are assessed through individual grading according to the 7-point scale or Pass/Fail. All modules are assessed by external examination (external grading) or internal examination (internal grading or assessment by the supervisor only). Unless stated otherwise, the modules are used for both tracks.

Semester	Modul	ECTS	Assessment	Exam	Type
1.	Project in Classic Production and Service Technologies (P0)	5	7-point scale	Internal	Mandatory
	Project in From the Classic to Modern Production and Service	10	7-point scale	Internal	Mandatory
	Materials and Manufacturing Processes	5	7-point scale	Internal	Mandatory
	Problem Based Learning in Science, Technology and Society	5	Pass/Fail	Internal	Mandatory
	Linear Algebra	5	7-point scale	Internal	Mandatory
2.	Project in Product and Service Development	15	7-point scale	External	Mandatory
	Innovation Technology: Product Development & Product Service Design	5	7-point scale	Internal	Mandatory
	Calculus	5	7-point scale	Internal	Mandatory
	Reality and Models	5	7-point scale	Internal	Mandatory
3.	Project in Products, Processes and Automation	15	7-point scale	Internal	Mandatory
	New Materials and Processes	5	7-point scale	Internal	Elective track A
	Job Design	5	7-point scale	Internal	Elective track B
	Manufacturing Processes, Automation and Robots	5	7-point scale	Internal	Mandatory
	Digital Manufacturing Technology	5	7-point scale	External	Elective

					track A
	Digital Manufacturing and Service	5	7-point scale	External	Elective track B
4.	Project in Intelligent Manufacturing and Service design	15	7-point scale	External	Mandatory
	Introduction to Probability and Applied Statistics	5	7-point scale	Internal	Mandatory
	Industrial Vision, Sensors and Quality Control	5	7-point scale	Internal	Elective track A
	Engineering Design and Quality Control	5	7-point scale	Internal	Elective track B
	Intelligent Manufacturing	5	7-point scale	Internal	Elective track A
	Intelligent Production and Service Design	5	7-point scale	Internal	Elective track B
5.	Project in Operations and Service Management	15	7-point scale	External	Mandatory
	Introduction to Production and Service Economics	5	7-point scale	Internal	Mandatory
	Systems Thinking and Process Improvement	5	7-point scale	Internal	Mandatory
	Operations Planning and Control	5	7-point scale	Internal	Mandatory
6.	BSc Project	20	7-point scale	External	Mandatory
	Scientific Theory and Entrepreneurship	5	7-point scale	Internal	Mandatory
	Global Supply Chain Management	5	7-point scale	Internal	Elective
	Selected Topics in Intelligent Manufacturing	5	7-point scale	Internal	Elective
	Advanced Manufacturing and Service Information Systems	5	7-point scale	Internal	Elective
SUM		180			

On 3<sup>rd</sup> and 4<sup>th</sup> semester, respectively, students must choose 2 out of 4 elective courses. On the 6<sup>th</sup> semester students must choose 1 out of 3 elective courses.

Most courses introduce scientific methods, which are specific to the topic of the course. For instance are mathematical methods introduced in the courses Linear Algebra and Calculus, methods for robot programming Digital manufacturing technology etc. Scientific theory and scientific methods in general are included in the course Problem based learning in science, technology and society. Moreover, the students develop their skills in this area in their project work, where they will apply scientific methods in practice and reflect on their applicability in the subsequent process evaluation.

The Board of Studies of Industry and Global Business Development may decide that a course module's academic content in a semester is taught in the project module, which is increased in ECTS accordingly. The decision can be justified in terms of capacity or economy of the current semester.

### 3.2 Manufacturing and Operations Engineering, 1st semester

#### 3.2.1 Project in Classic Production and Service Technologies (P0)

**Title:** Classic Production and Service Technologies (5 ECTS)  
(Klassisk produktion og service teknologi)

**Prerequisites:** No special prerequisites for the module.

**Objectives:** Students who complete the module:

*Knowledge:*

- Knowledge about typical work processes in a problem based project
- Knowledge about the basic principles in scientific work e.g. academic honesty
- Must have knowledge of what the subject of innovative production development includes
- Must have knowledge about the concept of innovative production and services vs. the classic approaches to production and services
- Must be able to understand the concept of problem based learning

*Skills:*

- Analyze individual as well as organizational learning processes
- Organize a short period (less than a month) of collaboration in-group and with supervisor
- Communicate the reflections and results of the problem based project work; orally, graphically and in writing
- Must be able to apply problem based learning in group work
- Must be able to perform a simple SWOT analysis

Students who complete P0 project unit will have gained their first experience in using the problem-based learning method. Furthermore, students will be introduced to the discipline of innovative production development (IPD).

The students will be required to present a general conceptual approach within IPD. The concept must include the business aspects, considerations simulation vs. physical execution, a SWOT analysis and an actor analysis. An example application of IPD with focus on production suitable for the project could be an analysis of a classic production technology or of a technology central to a service system. Furthermore the students will be required to prepare a written P0 process analysis.

**Type of instruction:**

Students will do their project work in groups. The groups will receive instruction and feedback from the teacher.

**Exam format:**

Internal Oral examination based on a written project report.

**Evaluation criteria:**

Are mentioned in the framework provisions

### 3.2.2 Project in From the classic to modern production and service

**Title:** Project in From the Classic to Modern Production and Service (10 ECTS)  
(Projekt i Fra klassisk til moderne produktion og service)

**Prerequisites:** The students should have completed the module in: *Classic Production and Service Technologies (P0)*

**Objectives:**

To provide the student with practical experience defining a project within the area of innovative production development (IPD), which includes use innovative and agile production methods and services, to implement the project by working in groups and to document the solution in a project report. To give the students a common understanding of key challenges and developments in the field and to induce a shared feeling of belonging to the study programme.

Students who complete the module:

*Knowledge:*

- Knowledge about basic organizational theory
- Knowledge about IDP in order to identify relevant contextual perspectives of a given technology
- Knowledge about project management in a long-term problem based project (in this case 2-3 months)
- Knowledge of methodological consideration to describe the theoretical and empirical foundation of the project
- Must have knowledge about how modern innovation, production and service technology can be used to solve a specific problem
- Must have knowledge about commonly technologies and approaches for innovative and agile production and service
- Must have knowledge about commonly occurring production and service processes.
- Must have knowledge about the use of modern innovation, production and service technologies

*Skills:*

- Analyze individual as well as organizational processes by scientifically recognized concepts and methods
- Organize and manage a longer-term project considering group and supervisor collaboration
- Structure and communicate the reflections and results of the problem based project work; orally, graphically and in writing
- Must be able to work in a team
- Must be able to identify and define a problem suitable for a project involving innovation, agile production and service technologies
- Must be able to identify classic approaches in existing production and service implementations and compare these with modern approaches.
- Must be able to choose and use a specific approaches for innovative and agile production and service
- Must be able to plan a systematic test of a chosen production or service technology
- Must be able to discuss/assess the quality of the technology choice in a wider context

*Competencies:*

- Take responsibility of one's own learning during a longer-termed project period and be able to generalize the gained experiences

- Must have competencies for discussing and comparing classical production and service technologies vs. modern technological approaches
- Must have competences in document and discuss the wider market related implications of a real life application
- Must have competences to coordinate the project, to present the results and communicate the results and to

**Type of instruction:**

The course will alternate between discussion based lectures and project work. Students will do their project work in groups. The groups will receive instruction and feedback from the teacher. Students have to prepare a written P1 process analysis. Students will get support to identify relevant contextual perspectives by consultancy; a group meeting, and commenting on papers and presentation at the status seminar. Students will get support to transfer project management theory to the projects by a PBL-seminar and related to this comments on papers as well as presentations in order to secure action on a mid-term process-analysis. A written comment to the group's process analysis will be provided to support project-examination.

**Exam format:**

Internal. Oral examination based on a written project report.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.2.3 Materials and Manufacturing Processes

**Title:** Materials and Manufacturing Processes (5ECTS)  
(Materialer og mekaniske processer)

**Prerequisites:** No special prerequisites for the module.

**Objectives:**

To provide the student with a foundation for the properties and applications of different materials and manufacturing processes.

The student should acquire an understanding of basic properties of materials and typical manufacturing processes. This provides a foundation for students to select materials and manufacturing processes bridging idea and production.

Students who complete the module:

*Knowledge:*

- Must have knowledge about commonly used materials, and their related properties and the required manufacturing processes.
- Must have knowledge about commonly used manufacturing processes

*Skills:*

- Must be able to choose and use a specific material according to a specified product and production requirement.
- Must be able to choose and use the right manufacturing processes for a given material and desired outcome.
- Must be able to discuss/assess the quality of process outcome.

*Competencies:*

- Must have competencies in choosing and using the right material and manufacturing process for a specific desired outcome.

**Type of instruction:**

Lectures, use of workshops, experiments with materials.

**Exam format:**

Internal. Oral examination based upon mandatory assignments.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.2.4 Problem Based Learning in Science, Technology and Society

**Title:** Problem Based Learning in Science, Technology and Society (5 ECTS)  
(Problembaseret læring i videnskab, teknologi og samfund (PBL))

**Prerequisites:** No special prerequisites for the module.

**Objectives:**

The students shall theoretically as well as practically understand how to plan and execute a scientific problem-based project with technological, social and humanistic relevance. This includes an understanding of how technological aspects and contextual circumstances can be identified and included in the development of a problem solution.

Students who complete the module:

*Knowledge:*

- Must have knowledge of basic learning theories
- Must have knowledge of project planning and managements techniques
- Must have knowledge of different approaches to problem-based learning (PBL); including the Aalborg model approach, where problems are related to social and/or humanistic contexts
- Must have understanding of different resources for analysis and assessment of problems and solutions related to innovative production development from scientific, technological, ethical and social perspectives
- Must apply methods for analysis and assessment of problem within the field of innovative production development; including market and stakeholder analysis; and technologies and services assessments

*Skills:*

- Must be able to apply basic principles related to planning and management of a problem-based project; basic study techniques, phases in a problem-oriented project, from initial problem to problem analysis and problem formulation, design and implementation
- Must be able to analyze and evaluate the organization of the project group work and collaboration, especially regarding identification of strong and weak factors, and, based on this, suggest how group organization and collaboration can be improved in future situations; team roles, group dynamics, communication within the group and externally, creativity, methods for analysis and documentation of learning processes
- Must be able to analyze group conflicts; causes and possible solution
- Must be able to analyze and evaluate own contribution to study and learning, especially regarding identification of strong and weak factors, and, based on this, consider continuous course of events and their contributions to the learning processes, learning styles and the study
- Must be able to analyze methods used in the project from a scientific point of view; science theory, qualitative and quantitative approaches
- Must be able to apply fundamental key areas, concepts and methods for evaluation and development of technical solutions considering the technology in itself, and in relation to social contexts and human circumstances (holistically); technology assessment methods, contexts and communication, media sociology (e.g. life styles, consumption, sociological methods), different forms of user test, innovation and creativity



*Competencies:*

- Must be able to apply knowledge (application) and understanding regarding being part of a team based project work
- Must be able to understand and communicate project work (application)
- Must be able to analyze own learning processes
- Must be able to analyze and document learning processes within the group (analysis)
- Must be able to create optimal collaborative learning processes (application)
- Must be able to apply knowledge and understanding of science, technology and society (application); from a technological perspective (including competencies on applying different technology assessment methods), and from a holistic perspective (including competencies on life style, consumption, and technology development, different contexts and forms of communication, innovative and creative processes)

**Type of instruction:**

Refer to the overview of instruction types listed in the start of chapter 3. The types of instruction for this course are decided according to the current Framework Provisions and directions are decided and given by The Study Board for Industry and Global Business Development.

**Exam format:**

Individual written report.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.2.5 Linear Algebra

**Title:** Linear Algebra (5ECTS)  
(Lineær algebra)

**Prerequisites:** No special prerequisites for the module.

**Objectives:**

Linear algebra is a fundamental tool for virtually all engineering mathematics.

Students who complete the module:

*Knowledge:*

- Shall have knowledge about definitions, results and techniques within the theory of systems of linear equations
- Shall be able to demonstrate insight into linear transformations and their connection with matrices
- Shall have obtained knowledge about the computer tool MATLAB and how it can be used to solve various problems in linear algebra
- Shall have acquired knowledge of simple matrix operations
- Shall know about invertible matrices and invertible linear mappings
- Shall have knowledge of the vector space  $\mathbb{R}^n$  and various subspaces
- Must have knowledge of linear dependence and independence of vectors and the dimension and bases of subspace
- Must have knowledge of the determinant of matrices
- Must have knowledge of eigenvalues and eigenvectors of matrices and their use
- Must have knowledge of projections and orthonormal bases
- Must have knowledge of first order differential equations, and on systems of linear differential equations
- Must know how use a programming language to program linear-algebra-related problems
- Must know how to use typical programming syntaxes such as conditional branching, loops, etc.

*Skills:*

- Must be able to apply theory and calculation techniques for systems of linear equations to determine solvability and to provide complete solutions and their structure
- Must be able to represent systems of linear equations using matrix equations, and vice versa
- Must be able to determine and apply the reduced Echelon form of a matrix
- Must be able to use elementary matrices for Gaussian elimination and inversion of matrices
- Must be able to determine linear dependence or linear independence of small sets of vectors
- Must be able to determine the dimension of and basis for small subspaces
- Must be able to program basic linear-algebra-related programs

*Competencies:*

- Shall demonstrate development of his/her knowledge of, understanding of, and ability to make use of, mathematical theories and methods within relevant technical fields
- Shall, given certain pre-conditions, be able to make mathematical deductions

- and arguments based on concepts from linear algebra
- Shall have basic programming skills to solve related mathematical problems.

**Type of instruction:**

Refer to the overview of instruction types listed in the start of chapter 3. The types of instruction for this course are decided according to the current Framework Provisions and directions are decided and given by The Study Board for Industry and Global Business Development.

**Exam format:**

Internal Oral or written examination.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.3 Manufacturing and Operations Engineering, 2nd semester

#### 3.3.1 Project in Product and Service Development

**Title:** Project in Product and Service Development (15 ECTS)  
(Projekt i produkt- og serviceudvikling)

**Prerequisites:** The students should have basic intuition about production and service processes.

**Objectives:** For students to develop key competences in how to use innovation technologies and simulation tools for the development of products and services. Overall the project balances around possibilities and limitations of innovation technologies, virtualization technologies, concepts, user and employee driven innovation and the necessary modelling of processes, products and services.

Students who complete the project:

*Knowledge:*

- Must have knowledge about methods for planning and developing products in order to identify, analyze and assess the contextual impacts and perspectives of a given product through virtualization and rapid prototyping and the impact for manufacturing.
- Must have knowledge about how to model the interaction between a potential user and a product through virtualization
- Must have good knowledge about the most important concepts in innovation technology such as for example VR, rapid prototyping, and design and a basic understanding of state-of-art production technologies.
- Must have knowledge about central innovation development models such as lean innovation, agile development, etc.
- Must have knowledge about development of requirement specifications as a basis for developing a product of service
- Must have basic knowledge about how compose teams, how to involve and motivate peers, and how to organized projects systematically

*Skills:*

- Analyze and model individual as well as organizational learning processes based on experiences from P0 and P1
- Must be able to apply product development models to an actual case
- Must be able to apply end-user interaction models as a basis for requirements specifications
- Must be able to apply innovation technologies and design and production technologies
- Must be able to develop a requirement specification for a given product or service
- Must be able to link user requirements with the requirement specification for a given product
- Must be able to evaluate an development project based on requirements
- Reflect on the construction and reconstruction of science and technology in a user and society perspective
- Relate the professional practice within the discipline to the needs of humans and different societies
- Analyze technical or natural scientific problems by use of social science methodology
- Assess the impacts on human and society from the proposed solutions
- Assess team competencies and project plans and risk
- To perform a stakeholder analysis

- Must be able to communicate the project ideas, goals and results to individuals with non-engineering background

*Competencies:*

- Manage a longer termed project independently
- Generalize the gained experiences with project management and put them into perspective of the future course of study
- Reflect on the ethical perspective of engineering and science and discuss implications of a responsible professional practice
- Must have competencies in development of a requirements specification
- Must have competencies in elicitation of end-user requirements and to translate these into the requirement specification for a specific product/service
- Must have competencies in user interaction models
- Must have competencies in product and/or service development by use of the innovation technologies and design and production technologies.
- Must have the competence to oversee and model the entire process from the innovation to the potential production.
- Must have the competence to coordinate an interdisciplinary project.
- Must have the competence to communicate with interdisciplinary project partners.

**Type of instruction:**

Students will do their project work in groups. In the groups the students will get support to identify, analyze and assess relevant contextual perspectives through co-supervision.

**Exam format:**

External. oral examination based on a written project report.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.3.2 Innovation Technology: Product development & Product service design

**Title:** Innovation Technology: Product development & Product service design (5ECTS)  
(Innovationsteknologi: produktudvikling & produkt-service-design)

**Prerequisites:** The students should have completed *Linear Algebra*.

**Objectives:** To provide the student with an understanding of modern technologies that support innovation and product and service development.

Students who complete the module:

*Knowledge:*

- Must have basic knowledge about organizational theory and design.
- Must have knowledge about innovation technologies and approaches such as rapid prototyping, virtual reality and modelling and simulation
- Must have basic knowledge about design and state-of-art production technologies

*Skills:*

- Must be able to use innovation technology within the innovation process
- Must be able to identify the key advantages of the different technologies and use exploit them to optimally support the innovation process
- Must be able to combine different technologies as necessary
- Must be able to communicate the innovation results
- Must be able to involve end-users and stake holders into the virtualized innovation process
- Must be able to related innovation processes to organizational designs

*Competencies:*

- Must have the competence to optimize the innovation process using innovation technology to proto-type, simulate and virtualize the innovated product and service

**Type of instruction:**

Classroom teaching with assignments.

**Exam format:**

Internal. Oral examination based on mandatory course assignments.

**Evaluation criteria:**

Are mentioned in the framework provisions .

### 3.3.3 Calculus

**Title:** Calculus (5ECTS)  
(Calculus)

**Prerequisites:** The students should have completed *Linear Algebra*.

**Objectives:** Calculus is the branch of mathematics that studies differential equations and operations such as integration. Differential equations are necessary for describing control models, Calculus in general provides key tools for, e.g., operations research.

Students who complete the module:

*Knowledge:*

- Must have knowledge of definitions, results and techniques within the theory of differentiation and integration of functions of two or more variables
- Must have knowledge of the trigonometric functions and their inverse functions
- Must have knowledge of complex numbers, including rules for computation and their representations
- Must have knowledge of factorization of polynomials over the complex numbers
- Must have knowledge of the complex exponential function, its characteristics and its connection with trigonometric functions
- Must have knowledge of curves in the plane (both rectangular and polar coordinates) and spatial parameterizations, tangent vectors and curvatures of such curves
- Must have knowledge of the theory of second order linear differential equations with constant coefficients
- Must know how to program calculus-related problems and how to visualize results

*Skills:*

- Must be able to visualize functions of two and three variables using graphs, level curves and level surfaces
- Must be able to determine local and global extrema for functions of two and three variables
- Must be able to determine area, volume, moment of inertia etc. using integration theory
- Must be able to approximate functions of one variable using Taylor's formula, and use linear approximations for functions of two or more variables
- Must be able to perform arithmetic computations with complex numbers
- Must be able to find the roots in the complex quadratic equation and perform factorization of simple polynomials
- Must be able to solve linear second order differential equations with constant coefficients, in general, and with initial conditions
- Must be able to use the concepts, findings and theories introduced in the course to make mathematical deductions in the context of simple and concrete abstract problems
- Must be able to use programming techniques to solve and visualizing calculus-related problems.

*Competencies:*

- Shall demonstrate development of his/her knowledge of, understanding of, and ability to make use of, mathematical theories and methods within relevant technical fields

- Shall, given certain pre-conditions, be able to make mathematical deductions and arguments based on concepts from multi-variable calculus
- Shall have programming skills to solve and visualize related mathematical problems.

**Type of instruction:**

The teaching in Discrete mathematics is a combination of sessions with lectures and students solving problems, either manually or by using Matlab. Furthermore a selection of problems must be solved and handed in during the course.

**Exam format:**

Internal. Oral or written examination.

**Evaluation criteria:**

Are mentioned in the framework provisions.



### 3.3.4 Reality and Models

**Title:** Reality and Models (5ECTS)  
(Virkelighed og modeler)

**Prerequisites:** The students should have completed *Linear Algebra* and the project module *From the Classic to the Modern Production and Service*.

**Objectives:** For students to develop an understanding of the differences between models and reality. The overall objective is to make students realize, quantify, acknowledge and mediate the limits of models with respect to social, environmental and the overall physical reality.

Students who complete the module:

*Knowledge:*

- To acquire knowledge of the scientific way of working with emphasis on methods, theories and models.
- Must obtain knowledge about the models / theories and / or methods that are relevant and well defined in the state of art.
- Must acquire knowledge of relevant concepts and methods of analysis and assessment of scientific solutions in relation to people, the environment, society and the overall physical reality.
- Must be able to define and understand the model concepts and have a basic understanding of the methods, theories and/or models.

*Skills:*

- Must be able to define the problem objectives and a strategy for problem treatment and be able to analyze and draw conclusions with the involvement of relevant contexts.
- Must be able to assess the relevance of information that was collected in conjunction with the project.
- Must be able to include and describe relevant concepts, models, theories and methods used for analysis of the chosen problem.
- Must be able to quantitatively and qualitatively compare the employed models with the physical, social and environmental reality.
- Must be able to identify the right set of experiments to verify the model quality with respect to the physical, social and environmental reality.

*Competencies:*

- Must be able to communicate the results obtained from using a model to an audience that is not familiar with the model.
- Must be able to rationalize and scientifically justify the use of a specific model for a given problem.
- Must be able to work with a model while taking into account deviations to reality.
- Must be able to draw conclusions from a model while taking into account deviations to reality, and must be able to communicate the results.

**Type of instruction:**

The project is implemented in project teams with a maximum of 7 members per group. Students are given a theme that focuses on the engineering approach to modeling / analysis of reality in mechanical and production program and a project directory with project proposals from different academic environments in the engineering and production training. The students may use simulation or programming to illustrate the models and analysis.

**Exam format:**

Internal. Oral examination based on a written project report.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.4 Manufacturing and Operations Engineering, 3rd semester

#### 3.4.1 Project in Product, Processes and Automation

**Title:** Project in Product, Processes and Automation (15ECTS)  
(Projekt i Produkt, Processer og Automation)

**Prerequisites:** The students should have completed *Linear Algebra* and the project module *From the Classic to the Modern Production and Service*.

**Objectives:** While the focus of the previous project module was on the development of products and services as well as on the tools to support the innovation process, the purpose of this project module is to acquire knowledge, skills and competencies regarding the realization of these innovations.

Students who complete the project:

##### *Knowledge:*

- Must have knowledge about computer networks
- Must have knowledge about distributed information technology systems including protocol design and system architecture
- Must have knowledge about key components of manufacturing, production and service processes
- Must have knowledge about the most important concepts of state-of-art production technologies.
- Must have knowledge about the most important state-of-art networking and coordination technologies.
- Must know about the differences between digital models of manufacturing, production and service processes and their physical counterparts.

##### *Skills:*

- Must be able rationalize about existing manufacturing, production and service processes
- Must be able to digitally model manufacturing, production and service processes
- Must be able to map the digital models into reality.
- Must have basic knowledge about key concepts of computer science, incl. logic, syntax, automation theory and programming.
- Must be able to use a programming language to implementing basic approaches in manufacturing technologies and distributed information technology systems, incl. robots, databases

##### *Competencies:*

- Must demonstrate competences in performing analyses of organizational requirements for production, manufacturing and service implementation
- Must have competences in presenting manufacturing, production and service scenarios based on specific needs
- Must have competences in choosing relevant technology systems meeting organizational needs for manufacturing, production and services.
- Must have the principal competence to program relevant technological systems
- Must have the competence to summarize and present the results and consequences of such a technological project to non-engineers
- Must be able to relate technical details to non-technical project partners.

**Type of instruction:**

Students will do their project work in groups. The groups will receive instruction and feedback from the teacher.

**Exam format:**

Internal. Oral examination based on a written project report.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.4.2 New Materials and Processes

**Title:** New Materials and Processes (5ECTS, Track A)  
(Nye materialer og processer)

**Prerequisites:** The students should have completed the module *Materials and Mechanical Processes*.

**Objectives:** To provide the student with the use of new materials and mechanical processes. The student should acquire an understanding of the properties of new materials and their manufacturing processes to apply this knowledge during innovation and production processes.

Students who complete the module:

*Knowledge:*

- Must have knowledge about new materials, and their related properties and their manufacturing processes.
- Must have knowledge about the manufacturing processes used with new materials
- Must have knowledge about **innovation – advanced materials development**.

*Skills:*

- Must be able to choose and use a specific material according to a specified product and production requirement.
- Must be able to choose and use the right manufacturing processes for a given material and desired outcome.
- Must be able to discuss/assess the quality of process outcome.

*Competencies:*

- Must have competencies in choosing and using the right material and mechanical process for a specific desired outcome.
- Must be able to identify opportunities offered by new materials for the production innovation process as well as for the manufacturing and production process.

**Type of instruction:**

Lectures, external lecturers (from companies working with new materials), external visits, group work, presentations by students, exercises.

**Exam format:**

Internal. Oral exam based on synopsis.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.4.3 Job Design

**Title:** Job Design (5 ECTS, Track B)  
(Job design)

**Prerequisites:** The students should have completed the module *Reality and Models*.

**Objectives:** To provide the student with an understanding of job design, ergonomics, and sustainable jobs.

From scientific management (Taylor) over human factors and human relations to sociotechnical design and after sociotechnical design: the good work, developmental work, high performance work systems, lean, micro ergonomics, macro ergonomics

How to design a sustainable job: time and motion studies, involvement of workers, ergonomics, well-being, division of work, job enrichment and enlargement, psychological job demands, meaning  
Students who complete the module:

*Knowledge:*

- Must have knowledge about organizational theory and industrial relations
- Must have knowledge about classical job design theory and ergonomics
- Must have knowledge about sustainable jobs,
- Must have knowledge about psychosocial and physical working environment theory

*Skills:*

- Must be able to explain the classical history from scientific management to sociotechnical design and after.
- Must be able to use apply time and motion study techniques
- Must be able to explain theories of worker involvement
- Must be able to use job design techniques
- Must be able to discuss and evaluate the working environment of a workplace
- Must have the skill to communicate with individuals in an interdisciplinary setting.
- Must have the skill to communicate and motivate

*Competencies:*

- Must have the competencies to apply job design theories to create sustainable jobs

**Type of instruction:**

Classroom teaching with exercises in manufacturing lab facilities

**Exam format:**

Internal. Oral examination based on mandatory course assignments.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.4.4 Manufacturing processes, automation and robots

**Title:** Manufacturing Processes, Automation and Robots (5ECTS)  
(Fremstillingsprocesser, automatisering, robotter)

**Prerequisites:** Documented knowledge corresponding to passing second semester.

**Objectives:** To introduce the student to a number of different technologies for manufacturing and automation, incl. robots.

Students who complete the module:

*Knowledge:*

- Must have knowledge about key technologies for manufacturing and automation
- Must have knowledge about robots in particular
- Must have knowledge about relevant manufacturing and automation processes
- Must have basic knowledge about state-space modelling and control of automation processes

*Skills:*

- Must be able to choose the right manufacturing and automation technologies for a given product type and product material.
- Must be able identify the right robot technology for a given automation problem
- Must be able to relate the key technologies for manufacturing and automation to the relevant digital models.
- Must be able to program a automation technologies and robots

*Competencies:*

- Is able to map a product innovation into an automation process
- Is able to outline a manufacturing and automation process based on given needs
- Is able to program automation technologies and robots

**Type of instruction:**

The lessons consist of theory combined with practical exercises and are closely related to the project course consisting in the development of a manufacturing and automation system.

**Exam format:**

Internal Oral examination based on assignments.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.4.5 Digital Manufacturing

**Title:** Digital Manufacturing Technology (5ECTS, Track A)  
(Digitalisering af produktionsprocesser)

**Prerequisites:** The students should have completed the modules *Linear Algebra, Calculus, Reality and Models* and *Innovation Technology: Product development & Product service design*

**Objectives:** To provide the student with an understanding of modelling of processes and information flows. The course will introduce the students to basic techniques of digital manufacturing including logic, syntax, programming languages, and relational databases based on cases from manufacturing, service sector and the game industry.

Students who complete the module:

*Knowledge:*

- Must have basic knowledge about relational database theory
- Must have knowledge about programming logic, syntax and languages
- Must have knowledge about the virtualization technologies in for manufacturing processes

*Skills:*

- Must be able to perform logic and syntax analysis and descriptions.
- Must be able to use design and modelling tools for process description
- Must be able to discuss and evaluate digital prototypes
- Must be able to program basic robot control in simulation
- Must be able to implement simple robot control within an automation process
- Must be able to model manufacturing and automation processes using virtualization technologies.

*Competencies:*

- Must have the competencies to apply modelling techniques to cases of service and manufacturing processes and to develop simple robot applications.

**Type of instruction:**

Classroom teaching with exercises and creation of virtual prototypes.

**Exam format:**

External censor. Oral examination based on mandatory course assignments.

**Evaluation criteria:**

Are mentioned in the framework provisions.



### 3.4.6 Digital Manufacturing

**Title:** Digital Manufacturing and Service (5ECTS, Track B)  
(Digitalisering af produktions- og serviceprocesser)

**Prerequisites:** The students should have completed the modules *Linear Algebra, Calculus, Reality and Models and Innovation Technology: Product development & Product service design*

**Objectives:** To provide the student with an understanding of modelling of processes and information flows. The course will introduce the students to basic techniques of digital manufacturing including logic, syntax, programming languages, data mining, and relational databases based on cases from manufacturing, service sector and the game industry.

Students who complete the module:

*Knowledge:*

- Must have knowledge about relational database theory
- Must have knowledge about programming logic, syntax and languages
- Must have understand the relation between virtual and physical products/services
- Must understand the possibilities in crowd sourcing and open source

*Skills:*

- Must be able to explain relational database theory
- Must be able to use common database programming languages
- Must be able to perform logic and syntax analysis and descriptions.
- Must be able to use design and modelling tools for process description
- Must be able to explain theories of technological convergence across sectors
- Must be able to use techniques for user involvement and to evaluate digital prototypes
- Must be able to use a programming language to solve related problems

*Competencies:*

- Must have the competencies to apply modelling techniques to cases of service and manufacturing processes and to develop simple database applications.

**Type of instruction:**

Classroom teaching with exercises and creation of virtual prototypes.

**Exam format:**

External censor. Oral examination based on mandatory course assignments.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.5 Manufacturing and Operations Engineering, 4th semester

#### 3.5.1 Project in Intelligent Manufacturing and Service Design

**Title:** Project in Intelligent Manufacturing and Service Design (15ECTS)  
(Projekt i Intelligent Manufacturing and Service Design)

**Prerequisites:** The students should have completed the project module *Products, Processes and Automation*.

**Objectives:** To introduce the student to advanced technologies for manufacturing and service that go beyond the classic technologies, and give the student the ability to get familiar with new developments.

Students who complete the project:

*Knowledge:*

- Must have knowledge about key technologies for intelligent manufacturing and service design
- Must have knowledge about sustainable and modularized manufacturing
- Must have knowledge innovative and sustainable service design.

*Skills:*

- Must be able to discuss the advantages and disadvantages of intelligent manufacturing and service design in relation to specific services and applications
- Must be able to identify intelligent solutions and state-of-art technologies for intelligent manufacturing and service design
- Must be able to familiarize him/herself with new manufacturing and service technologies

*Competencies:*

- Must have competencies in applying project- and team-based learning to complete a team project, including preparation of problem definition, coherent analysis and writing of a technical report with clear formulation of results and conclusions, and with proper use of source references
- Must have competencies in assessing the usefulness of intelligent manufacturing and service design technologies in relation to different services and applications
- Must have the competencies in deploying the knowledge, skills and competencies acquired in the course "Intelligent Manufacturing (and Service Design)" developing this project.

**Type of instruction:**

Students will do their project work in groups. The groups will receive instruction and feedback from the teacher.

**Exam format:**

External. Oral examination based on a written project report.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.5.2 Introduction to Probability and Applied Statistics

**Title:** Introduction to Probability and Applied Statistics (5ECTS)  
(Introduktion til sandsynlighedsregning og anvendt statistik)

**Prerequisites:** *Calculus* and *Linear Algebra* as taught at 1st and 2nd semester.

**Objectives:** To introduce the student to concepts and ideas within statistics and how statistics can be applied to problems relevant to engineers in this education.

Students who complete the course module will obtain the following qualifications:

*Knowledge:*

- Fundamental concepts in probability, including conditional probability and independence.
- Discrete and continuous random variables and relevant properties of these.
- Various examples of descriptive statistics, e.g. histograms and scatterplots.
- Statistical inference, including estimation, confidence intervals and hypothesis testing.
- Important statistical models, like linear regression (simple and multiple), analysis of variance, logistic regression and log-linear models (in particular contingency tables).

*Skills:*

- Can, given specific data, specify a relevant statistical model and account for the assumptions and limitations of the chosen model.
- Must be able to use relevant software and programming for carrying out the statistical analysis of given data and be able to interpret the results of the analysis.

*Competencies:*

- Must be able to judge the applicability of statistics within own area.
- Is capable of performing a critical judgement of the results of a statistical analysis.
- Should be capable of communicating the results of a statistical analysis to people with no or little background within statistics.

**Type of instruction:**

Lectures in combination with practical problems from the education, and self-study.

**Exam format:**

Internal. Oral or written examination.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.5.3 Industrial Vision, sensors and quality control

**Title:** Industrial Vision, Sensors and Quality Control (5ECTS, Track A)  
(Industriell billedbehandling, sensorer og kvalitetskontrol)

**Prerequisites:** The students should have completed *Digital Manufacturing Technology* or *Digital Manufacturing Models*.

**Objectives:** To provide the student with an understanding of state-of-art sensory devices for automation control (AC) and quality control (QC).

Students who complete the module:

*Knowledge:*

- Must have knowledge about engineering design
- Must have knowledge about quality control principles
- Must have knowledge about state-of-art sensory devices, such as temperature, touch, vision

*Skills:*

- Must be able to explain typical application of sensors for AC and QC
- Must be able to use common sensory devices for AC and QC, in particular visual sensors as the most general one.
- Must be able to rationalize and justify a specific choice of sensor for a given application w.r.t. technical capabilities and cost.
- Must be able to discuss and evaluate the use of a specific sensor choice for a given application problem.

*Competencies:*

- Must have the competencies to apply design rules, principles and guidelines

**Type of instruction:**

Lectures in combination with practical exercises and self-study.

**Exam format:**

Internal. Oral or written examination.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.5.4 Engineering Design and Quality Control

**Title:** Engineering Design and Quality Control (5ECTS, Track B)  
(Engineeringdesign og kvalitetskontrol)

**Prerequisites:** The students should have completed *Digital Manufacturing Technology* or *Digital Manufacturing Models*.

**Objectives:** To provide the student with an understanding of the basic steps and activities involved in creating novel systems, solutions, concepts, products, or services - the student should have an understanding of the nature of engineering work and design processes. Furthermore, the student should have an understanding of the core principles of quality control and the way in which quality can be ensured throughout the design processes.

Students who complete the module:

*Knowledge:*

- Must have knowledge about engineering design
- Must have knowledge about quality control principles typically used in the design process
- Knowledge about the intersection between engineering design and quality related issues.

*Skills:*

- Must be able to explain typical design principles, rules as well as quality control tools and techniques
- Must be able to explain the typical quality controls tools and techniques used in the design process.
- Must be able to use common design principles and rules in connection with the design process
- Must be able to use quality control tools and techniques in the engineering design process
- Must be able to address key trade-offs in the design process
- Must be able to discuss and evaluate the effectiveness, efficiency and value of design principles, rules, as well as quality control tools and techniques.

*Competencies:*

- Must have the competencies to apply design rules, principles and guidelines in connection with the creation novel systems, solutions, concepts, products, or services.

**Type of instruction:**

Classroom teaching with case examples and exercises.

**Exam format:**

Internal. Oral examination based on mandatory course assignments.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.5.5 Intelligent Manufacturing

**Title:** Intelligent Manufacturing (5ECTS, Track A)  
(Intelligent produktion)

**Prerequisites:** The students should have completed *Digital Manufacturing Technology* or *Digital Manufacturing Models* and *Manufacturing Processes, Automation and Robots* and *Calculus* and *Linear Algebra*

**Objectives:** To provide the student with an understanding of advanced technologies for manufacturing and service that go beyond the classic technologies, and give the student the ability to get familiar with new developments.

Students who complete the module:

*Knowledge:*

- Must have knowledge about sustainable manufacturing and service development
- Must have knowledge about state-of-art in intelligent manufacturing technology
- Must be able to familiarize him/herself with new manufacturing and service technologies

*Skills:*

- Must be able to explain principles of agile manufacturing
- Must be able to explain core principles of service development
- Must be able to rationalize about advances and disadvantages of intelligent manufacturing technology
- Must be able to use and optimize an intelligent manufacturing technology for a given problem
- Must be able to rationalize about costs and effectively of intelligent manufacturing technology
- Must be able to discuss and evaluate an existing use of intelligent manufacturing technology

*Competencies:*

- Must have the competencies to apply principles of agile and sustainable manufacturing to company cases
- Must be able to apply intelligent manufacturing technologies to a given problem at hand.

**Type of instruction:**

The lessons consist of theory combined with practical exercises and are closely related to the project course consisting in the development of a manufacturing and automation system.

**Exam format:**

Internal. Oral examination based on mandatory course assignments.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.5.6 Intelligent Production and Service Design

**Title:** Intelligent Production and Service Design (5ECTS, Track B)  
(Intelligent produktion og servicedesign)

**Prerequisites:** The students should have completed *Digital Manufacturing Technology* or *Digital Manufacturing Models* and *Manufacturing Processes, Automation and Robots, Calculus and Linear Algebra*

**Objectives:** To provide the student with an understanding of how contemporary technologies – for innovation, design, and manufacturing of products or delivery services – can be applied to create responsive, sustainable, and agile production and service delivery systems in a company.

Students who complete the module:

*Knowledge:*

- Must have knowledge about intelligent production and service development
- Must have knowledge about organizational design facilitating intelligent production
- Must have knowledge about the role of management and humans in intelligent production
- Must have knowledge about communication protocols and software platforms

*Skills:*

- Must be able to explain principles of agile manufacturing and how they influence the design process
- Must be able to explain core principles of service development and how they influence the design process
- Must be able to use the principles, tool and techniques of agile manufacturing and service design in the process of intelligent production and service systems
- Must be able to combine different principles tools and techniques to create intelligent production and service systems
- Must be able to discuss and evaluate the appropriateness of a given intelligent production and service system and how to balance conflicting demands in the design process

*Competencies:*

- Must have the competencies to apply principles of agile and sustainable production to company cases and design intelligent production and service systems
- Must have competencies to establish involving, flexible processes involving stakeholders at all levels in innovation processes

**Type of instruction:**

Classroom teaching with case examples and exercises

**Exam format:**

Internal. Oral examination based on mandatory course assignments.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.6 Manufacturing and Operations Engineering, 5th semester

#### 3.6.1 Project in Operations and Service Management

**Title:** Project in Operations and Service Management (15ECTS)  
(Prosjekt i Operations og Service Management)

**Prerequisites:** Documented knowledge corresponding to passing fourth semester

**Objectives:** To enable students to develop models for advanced global, organizational and technical systems based on state-of-the-art virtualization technologies and the knowledge and skills acquired during the previous semesters. The project should make use of solid skills in operations research and management, logistics, etc. based on the system and user requirements.

Students who complete the project:

*Knowledge:*

- Will have knowledge about operations and service management
- Will have knowledge about global systems, organizational and technical systems
- Will have knowledge about operations research
- Will have knowledge about interface management

*Skills:*

- Will be able to understand and overcome limitations of operations and service management
- Will be able to develop operations procedures
- Will be able to make qualified decisions for organizational and technical systems
- Will be able to work with supply chains, inventory capacity management and logistics
- Will be able to model global systems, organizational and technical systems using virtualization technologies

*Competencies:*

- Will have competencies in modelling global, organizational and technical systems based on state-of-the-art virtualization technologies.
- Will have competencies to model and analyse supply chains, inventory capacity management and logistical needs of a given system
- Will have competences to apply operations research for forecasting, inventory capacity management and logistical processes

**Type of instruction:**

Students will do their project work in groups. The groups will receive instruction and feedback from the teacher.

**Exam format:**

External. Oral examination based on a written project report.

**Evaluation criteria:**

Are mentioned in the framework provisions.



### 3.6.2 Introduction to Production and Service Economics

**Title:** Introduction to Production and Service Economics (5ECTS)  
(Introduktion til produktions- og serviceøkonomi)

**Prerequisites:** The students should have completed *Calculus*

**Objectives:** To provide the student with an understanding of fundamentals of management accounting, business economics and finance in a manufacturing context. Students who complete the module should understand the basics within management accounting, business economics and finance in a manufacturing context.

Students who complete the project:

*Knowledge:*

- Must have knowledge about principles of manufacturing and service economy at business level
- Must have knowledge about main principles of management accounting and business economics
- Must have knowledge about financial ratios and profitability analysis (du-pont pyramid, ROI, ROA, financial leverage etc.)
- Must have knowledge about quoting and pricing calculations
- Must have knowledge about budgeting and cash-flow analysis
- Must have knowledge about investment-theory and pay back analysis, also be familiar with Monte carlo and sensitivity analysis
- Must have knowledge about make-buy analysis to guide in- versus outsourcing decisions in a short but also long term context
- Must have an understanding of business models
- Must have an understanding of the balance between demand-pull and push

*Skills:*

- Must be able to understand and contribute to annual report and balance sheet for a “constructed” business setup
- Must be able to analyze profitability and economic performance of businesses through review of financial ratios and underlying assumptions
- Must be able to produce a viable quote or offer a price for a customer on a particular product / service offering
- Must be able to make simple budgeting and cash-flow analysis of investments
- Must be able to produce cost-benefit analysis of “hard” and “soft” investments and calculate Net present value for these, also make scenario based analysis of returns
- Must be able to examine profitability of make buy-decisions for manufacturing / logistics chains in a global context, examining both short and long term benefits

*Competencies:*

- Must have the competencies to apply management accounting and business economics to systematize economic decision at the manufacturing, value chain or business level
- Must have the competencies to make financial plans for start ups, price new products / services from a cost based perspective etc, and this to enable successful entrepreneurial activities among students

**Type of instruction:**

Classroom teaching with exercises and game supported learning (economic games).

**Exam format:**

Internal. oral examination.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.6.3 Systems Thinking and Process Improvement

**Title:** Systems Thinking and Process Improvement (5ECTS)  
(Systemt enkning og procesudvikling)

**Prerequisites:** Students must have completed *Introduction to Probability and Applied Statistics*, and either *Industrial Vision, Sensors and Quality Control* or *Engineering Design and Quality Control*

**Objectives:**

Students who complete the project:

*Knowledge:*

- A coherent and profound understanding of approaches, tools and techniques of systems thinking and business process improvement approaches, as Lean, Six Sigma, TPM, TQM to be used for continuous improvement, i.e. simplification, standardization, automation of business processes in industry and service organizations

*Skills:*

- Master various principles, tools and techniques to be applied in business improvement projects, as e.g. SIPOCs, process mapping, value stream mapping, KPI and PPI analysis, root cause analysis, control charts, box plots, regression analysis, 5S, value, waste, 5Rs for process redesign, flow, pull, jidoka, pokayoke, cash flow analysis, stakeholder management etc.
- Skills in leading operations and business process improvement projects as well as kaizen activities according to Systems Thinking, PDCA or DMAIC methods
- Skills in leading operations and business improvement projects towards meeting deliverables and broader stakeholder objectives, also taking role of human resources into account
- Skills for designing and leading larger scale organizational transformations centered around lean-six sigma approaches towards sustainable practices of continuous improvement – also ability to identify enablers / barriers for success, e.g. the role that governance of IT investments play in enabling process improvement projects to succeed

*Competencies:*

- Be able to deploy knowledge and skills in relation to business process improvement (Lean-Six Sigma, TPM, TQM) challenges of manufacturing, transportation or service organizations
- Be able to deploy knowledge and skills in relation to larger scale organizational transformations targeting a kaizen / continuous improvement culture
- Develop abilities to do project and stakeholder management of business improvement projects in own organization

**Type of instruction:**

Class teaching, games, cases, exercises and one group project.

Approximately 60% of the time will be spent on exercises and the group project.

**Exam format:**

Internal. Oral examination based on project.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.6.4 Operations Planning & Control

**Title:** Operations Planning & Control (5ECTS)  
(Produktionsplanlægning og kontrol)

**Prerequisites:** The student must have completed *Industrial Vision, Sensors and Quality Control* or *Engineering Design and Quality Control*

**Objectives:**

Students who complete the project:

*Knowledge:*

- Have gained knowledge about planning and control methods for production and service systems and the supporting IT-systems
- Have gained knowledge of a number of time series methods for forecasting
- Have gained knowledge of inventory management methods and their applications

*Skills:*

- Be able to develop and evaluate the performance of a suitable time series forecasting model based on real data
- Be able to conduct a Material Requirements Planning break down
- Be able to choose planning and control methods depending on the context and composition of the production or service system
- Be able to design and redesign planning and control systems in production and service management companies adapted to a company's specific situation

*Competencies:*

- Be able to combine a number of mathematical tools in an appropriate manner to design a comprehensive planning and control system

**Type of instruction:**

Class teaching, lab exercises and one group project.

**Exam format:**

Internal. Oral examination based on project.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.7 Manufacturing and Operations Engineering, 6th semester

#### 3.7.1 BSc Project

**Title:** BSc Project (20ECTS)  
(Bachelorprojekt)

**Prerequisites:** The students should have followed the semesters 1-5 and have completed the mandatory modules and most of the elective.

**Objectives:** To demonstrate the totally acquired knowledge, skills and competencies as described for this bachelor study program (cf. chapter 2 and 3 of this document).

Students who complete the project:

*Knowledge:*

- Must have knowledge of how to design and develop a solution to an Manufacturing and Operation Engineering related problem serving the needs of the end user

*Skills:*

- Must be able to identify and apply organizational, market and technical implications of a given solution to a problem
- Must be able to develop new solutions or improve existing ones to new problems related to Manufacturing and Operation Engineering.

*Competencies:*

- Must show command of the competencies acquired in the semesters 1-5

**Type of instruction:**

Students will work individually or in groups. The students will receive instruction and feedback from the teacher.

**Exam format:**

External assessment.

Assessment is based on a written report and oral presentation followed by oral examination. If a project includes development of a prototype, this shall be demonstrated during the examination.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.7.2 Philosophy of Science and Entrepreneurship

**Title:** Scientific Theory and Entrepreneurship (5ECTS)  
(Videnskabsteori og entrepreneurskab)

**Prerequisites:** The students should have completed *Systems Thinking and Process Improvement* and *Reality and Models*

**Objectives:**

Students who complete the project:

*Knowledge:*

- Must have knowledge of the engineering profession traditions, basic assumptions and the engineer's role in society, and ethical issues in engineering science.
- Must have knowledge of theoretical directions and traditions (objectivism / subjectivism) and conception of the world, knowledge and learning paradigm concept, engineering and concept of truth.
- Must have knowledge of possible career directions in engineering, including as advisory, project manager, researcher, etc.
- Must have knowledge of entrepreneurship, including opportunities to start their own business

*Skills:*

- Must be able to apply theoretical methods and concepts in the engineering profession disciplines.
- Must be able to plan their own careers.
- Must be able to handle starting a business.
- Must be able to analyze companies' organizational forms.
- Must be able to explain a product or solution innovative content and opportunities.
- Must be able to reflect on a company's management of innovation.

*Competencies:*

- Must be able to be part of the daily work in a company.
- Must be able to work interdisciplinary

**Exam format:**

Internal. Oral examination based on mandatory course assignments.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.7.3 Global Supply Chain Management

**Title:** Global Supply Chain Management (5ECTS)  
(Global Supply Chain Management)

**Prerequisites:** The students should have *Operations, Planning and Control*

**Objectives:**

To provide the student with an understanding of the theories and factors influencing the configuration of global supply chain.

Students who complete the module should understand and design global value chains.

*Knowledge:*

- Must have knowledge about theories about make-or-buy, transaction costs, relational view of the firm and the resource-based view of the firm outsourcing, offshoring, logistics, supplier selection and locational theories

*Skills:*

- Must be able to explain the important factors behind outsourcing decisions
- Must be able to explain core principles in location theory
- Must be able to analyze and design global supply chains.

*Competencies:*

- Must have the competencies to apply theories in designing global supply chains

**Type of instruction:**

Classroom teaching with cases

**Exam format:**

Internal. Oral examination based on mandatory course assignments.

**Evaluation criteria:**

Are mentioned in the framework provisions.

### 3.7.4 Selected topics in Intelligent Manufacturing

**Title:** Selected Topics in Intelligent Manufacturing (5ECTS)  
(Udvalgte emner i Intelligent Manufacturing)

**Prerequisites:** The students should have completed *Systems Thinking and Process Improvement* and *Reality and Models*, *Digital Manufacturing Technology* or *Digital Manufacturing Models* and *Manufacturing Processes, Automation and Robots*

**Objectives:**

Students who complete the module:

*Knowledge:*

- Must have knowledge about selected intelligent manufacturing technologies (IMTs)
- Must have knowledge about advantages and disadvantages of selected IMTs

*Skills:*

- Must be able to explain selected IMTs
- Must be able to evaluate and rationalize about selected IMTs
- Must be able to compute the costs and the profits from using a specific IMTs
- Must be able to analyze organizations and stakeholders
- Must be able to discuss and evaluate project plans

*Competencies:*

- Must have the competencies to apply theories of organizational design and to use project management tools

**Type of instruction:**

Classroom teaching with case exercises. Company visits.

**Exam format:**

Internal. Oral examination based on mandatory course assignments.

**Evaluation criteria:**

Are mentioned in the framework provisions.



### 3.7.5 Advanced manufacturing and service information systems

**Title:** Advanced Manufacturing and Service Information Systems (5ECTS)  
(Avancerede informationssystemer i fremstillings- og servicesektoren)

**Prerequisites:** The students should have completed *Introduction to Probability and Applied Statistics* and either *Digital Manufacturing Technology*, or *Digital Manufacturing Models*

**Objectives:**

To provide the student with an understanding of information systems within application areas in manufacturing and service and provide theories and tools for modelling data architectures, designing databases and data- warehouses, prototyping, and data mining.

Students who complete the module:

*Knowledge:*

- Must have knowledge about advanced information systems design and applications
- Must have knowledge about the role of information systems in manufacturing and service

*Skills:*

- Must be able to explain role of information systems in manufacturing and service
- Must be able to explain the interaction between information systems and business models
- Must be able to use advanced tools for programming databases
- Must be able to use tools for information and process modelling
- Must be able to discuss and evaluate the adequacy of information systems in specific application areas

*Competencies:*

- Must have the competencies to apply data analysis, modelling and programming techniques

**Type of instruction:**

Classroom teaching combined with modelling and programming exercises. Visits to manufacturing and service sites.

**Exam format:**

Internal. Oral examination based on mandatory course assignments

**Evaluation criteria:**

Are mentioned in the framework provisions.

## **Chapter 4: Entry into Force, Interim Provisions and Revision**

The curriculum is approved by the Dean of the Faculty of Engineering and Science and enters into force as of September 2014.

In accordance with the Framework Provisions for the Faculty of Engineering and Science at Aalborg University, the curriculum must be revised no later than 5 years after its entry into force.

## **Chapter 5: Other Provisions**

### **5.1 Rules concerning written work, including the Bachelor's project**

In the assessment of all written work, regardless of the language it is written in, weight is also given to the student's spelling and writing ability, in addition to the academic content. Orthographic and grammatical correctness as well as stylistic proficiency are taken as a basis for the evaluation of language performance. Language performance must always be included as an independent dimension of the total evaluation. However, no examination can be assessed as 'Pass' on the basis of good language performance alone; similarly, an examination normally cannot be assessed as 'Fail' on the basis of poor language performance alone.

The study board can grant exemption from this in special cases (e.g., dyslexia or a native language other than Danish).

The Bachelor's project must include an English summary. The summary must be at least 1 page and not more than 2 pages (this is not included in any fixed minimum and maximum number of pages per student). The summary is included in the evaluation of the project as a whole.

### **5.2 Rules concerning credit transfer (merit), including the possibility for choice of modules that are part of another program at a university in Denmark or abroad**

In the individual case, the study board can approve successfully completed (passed) program elements from other Master's programs in lieu of program elements in this program (credit transfer). The study board can also approve successfully completed (passed) program elements from another Danish program or a program outside of Denmark at the same level in lieu of program elements within this curriculum. Decisions on credit transfer are made by the study board based on an academic assessment. See the Framework Provisions for the rules on credit transfer.

### **5.3 Rules concerning the progress and completion of the Bachelor's program**

The student must participate in all first year examinations by the end of the first year of study in the Bachelor's program, in order to be able to continue the program. The first year of study must be passed by the end of the second year of study, in order that the student can continue his/her Bachelor's program.

In special cases, however, there may be exemption from the above if the student has been on a leave of absence. Leave is granted during first year of study only in the event of maternity, adoption, military service, UN service or where there are exceptional circumstances.

#### **5.4 Rules concerning the completion of the Bachelor's program**

The Bachelor's program must be completed no later than six years after it was begun.

#### **5.5 Special project process**

In the 3rd, 4th and 5th semesters, the student can upon application, design an educational program where the project work is replaced by other study activities; cf. the Framework Provisions section 9.3.1.

#### **5.6 Rules for examinations**

The rules for examinations are stated in the Examination Policies and Procedures published by the Faculty of Engineering and Science on their website.

#### **5.7 Exemption**

In exceptional circumstances, the study board can grant exemption from those parts of the curriculum that are not stipulated by law or ministerial order. Exemption regarding an examination applies to the immediate examination.

#### **5.8 Rules and requirements for the reading of texts in foreign languages and a statement of the foreign language knowledge this assumes**

It is assumed that the student can read academic texts and in modern English and use reference works and similar.

#### **5.9 Additional information**

The current version of the curriculum is published on the study board's website, including more detailed information about the program, including exams.