UNIVERSITY OF SOUTHERN DENMARK

Chapter 9

The programme specific part of the curriculum for:

Diplomingeniør i Mekatronik
Bachelor of Engineering in Mechatronics

Curriculum 2012, Version 1.0

Applicable to students admitted September 2012 onwards

The curriculum is divided into general provisions (Chapters 1-8), a programme specific part (Chapter 9) and the module descriptions for the subjects studied for each programme. Students should familiarise themselves with all three parts in order to acquire a full overview of the rules that apply throughout the study programme.

§1 Job Profiles

An engineer with a Bachelor of Engineering degree in Mechatronics has broad knowledge of mechanics, electronics and software. Furthermore, the students have the possibility of specialising through the choice of elective courses from the MCI research programs – for instance in: Nanotechnology, Embedded Systems or Dynamic Mechatronic Systems. The study programme focuses on product development. The mechatronics engineer will typically find employment in companies which develop and sell mechatronic products. With broad general knowledge and special key competences the mechatronic engineer can occupy many different positions in the company. Typical job profiles include:

- Development Engineer
- Project Manager
- Consultant
- Project Sales
- Teaching

The mechatronic engineer will typically start the career as development engineer and will, in the course of a few years, have the opportunity of combining the technical work with managerial work.

The mechatronic engineer often participates in development processes across organisations and is involved in collaboration with external companies, nationally and internationally. Alternatively, the mechatronic engineer can become a specialist within specific technologies or start up his/her own company.

§2 The competency description of the study programme

The aim of the Bachelor of Engineering study programme in Mechatronics is to educate a development engineer with competencies in mechanics, electronics and software including the interplay between the technologies. The study programmes qualifies the graduate engineer to carry out, participate in or lead the development of mechatronic products.

A Bachelor of Engineering in Mechatronics from the University of Southern Denmark is characterised by mastering the following competencies:

- the ability to design and calculate mechanical designs;
- the ability to design and calculate electronic circuits;
- the ability to develop software for intelligent products;
- the ability to participate in a company's development department independently and together with others;
- the ability to apply technological knowledge and theories for the development of new products;
- knowledge and understanding of an enterprise's practical circumstances, methods, processes and engineering-related functions
- the ability to carry out development projects independently and in teams;
- the potential to become a project manager for product development assignments.

§3 The subject columns of the study programme

The competencies of the mechatronics engineer are built around students working on topics from five subject columns:

- the theoretical foundation in mathematical/physical modelling;
- dynamic conditions in mechatronic products – practical and theoretical;
- technologies, design and development;
- methods and personal learning; and
- specialisation.

The academic topics are interlinked during the individual semesters by semester themes. Throughout the course of study, students continually acquire the necessary academic knowledge, while at the same time gaining personal competencies. The columns include the following subjects and disciplines:

<u>The theoretical foundation in mathematical/physical modelling</u>

Consists principally of the academic fields: DYM, ESY, EPHYS, THER, CAE, with the following principal content:

DYM: Integration techniques; Differentiation techniques; Vectoral algebra; Matrices; Absolute speed and acceleration; Coordinate systems; Newton's laws; Work and energy; Momentum, angular momentum and their preservation.

ESY: Trigonometrical functions; Complex numbers; Differentiation/integration technique; Taylor series and L'Hôpital's rule; Electrical fields; Magnetic fields; Simple motors.

EPHYS: Laplace transformation; Fourier transformation; Z transformation.

MCTHER4: Principal theories of thermodynamics; Equation of energy; Equation of state; Momentum theorem; Equation of continuity; Open and closed systems; Circulatory processes; Flows in compressible and incompressible media; Momentum and forces caused by flows; Heat transmission.

MCCAE4: Analysis of linear, static and heat transfer problems in axial, plane and three dimensional models. Finite element analysis using the ANSYS simulation tool.

<u>Dynamic conditions in mechatronic products – practical and theoretical</u>

Consists principally of the academic fields: CYB, MCCOE6, MCCOE5, MECH1, MECH2, with the following principal content:

CYB: Cybernetics; Dynamic feedback systems; Planning; Estimation; Applied mathematics; Computer simulation; Mathlab; Modelling; Mechatronics.

MCCOE5: Modelling of dynamic systems; Model of DC motor; Transient analysis and frequency analysis; Stability of closed loop systems; Dimensioning of lead-lag and PID compensation; Computer simulations with MATLAB.

MCCOE6: State equations in analogue and digital form; State-space controller; Controllability and observability; Controller for reference input; Integral controller.

MECH1: Forces and couples; Isolation of mechanical systems made up of one or more solids; Dry friction; Torsion of circular members; Internal effects; Design of beams for bending; Kinematics and kinetics of rigid bodies: general equations of motion, translation, fixed-axis rotation, work, energy and power, impulse, momentum.

MECH2: Load diagrams; Tension; Bending; Torsion; 3D loads; Singularity functions; Combined stress; Mohr's circle; Static and dynamic load; Endurance limits; Wöhler and Goodman diagrams; Machine parts: shafts, bearings, springs.

<u>Technologies, design and development</u>

Consists principally of the academic fields: DES, MAP, EMB1, EMB2, SAA, ELEC, PWE, MCAEM6, with the following principal content:

DES: Modelling with primitive solid elements; Modelling with parametric solid elements; Modelling with curves and sketches; 3D assembly modelling with solid components; Design of technical drawings with section views and dimensions including tolerances; Making technical drawings on the basis of a 3D assembly model; Making an exploded view on the basis of a 3D assembly model; Making a parts list on the basis of a 3D assembly model.

MAP: Concepts and data for the mechanical, electrical, magnetic, thermal, physical and durability properties of materials; The coherence between the structures and the properties of metals and polymers; Methods to improve the basic properties of materials, including their strength; Different methods for materials testing; Modelling processes for metals and polymers; Application of programs and databases for the systematic selection of materials and processes; Work on tolerance indication and tolerance evaluation.

EMB1: Numbering systems; Programming in C, including: simple data types, control structures, functions, arrays, structs, pointers, bitwise operators, microcontroller systems.

EMB2: Logic components; Boolean algebra; Latches and flip-flops; State machines; Microcontroller hardware; Peripheral units; Interrupts.

SAA: Sensor characterisation; Accuracy and error estimation; Basic understanding of semiconductor materials; Electromechanical, thermal, radiation and electromagnetic transducers; Simple actuators.

ELEC: A/D and D/A converters; Operational amplifiers; Feedback; Diodes; Bipolar junction transistors; FET transistors; Transistor used as a switch; Computer simulations; Methods for EMC correct circuits.

PWE: Development of power electronics to drive actuators, motors, etc.

MCAEM6: Electromagnetics focusing on the solution of various electrical engineering and physical problems.

<u>Methods and personal learning</u>

Consists principally of the academic fields: SPRO1M, SPRO2M, SPRO3M, SPRO4M, EXS5, with the following themes and principal content:

SPRO1M: The Mechatronic Development Process. An introduction to the Mechatronics disciplines: concept, interdisciplinarity and particular focus on the development process. A mechatronic product is designed by applying the other skills acquired during the semester.

SPRO2M: Build Mechatronics. A mechatronic product is built that is capable of autonomous movement. The other subjects of the semester are the academic basis for the project.

SPRO3M: Develop Mechatronics. The focus is on the development of an intelligent, dynamic mechatronic product. Science Theory is introduced.

SPRO4M: Construct Mechatronics. The project for the semester is focused on power electronics and energy systems – in the context of mechatronic products) with focus on validating the quality of the developed product. Continuation of Science Theory.

EXS5: Experts in Teams. Students design a product concept that involves complex problems across subject groups. The report on the project is given in English and is conducted by teams composed of students from a number of different branches. Completion of Science Theory.

The projects enhance and develop personal and learning competencies, while at the same time the academic competencies are learned in depth and brought to maturity in "real" projects.

Internship

The student gains practical and theoretical experience as an employee in a company – working as an engineer.

Personal competencies: Commitment, Initiative, Responsibility, Ethics, Establishment, Ability to put personal learning into perspective.

Learning competencies: Selection, collection, analysis and assessment of data material; Communication of working results using approaches that require reflection, cooperation and independence.

Specialisation and electives

Focusing of competencies is done by choosing elective courses in the fourth and fifth semesters (15 ECTS points in total). The courses will be in the domain of the MCI research, - e.g.: Nanotechnology, Embedded Control Systems or Dynamic Mechatronic Systems.

§4 Semester themes

Semester	SEMESTER THEMES
7.	**Final Project**
6.	**Internship**
5.	**Construct Mechatronics**
4.	**Mechatronics and the Environment**
3.	**Develop Mechatronics**
2.	**Build Mechatronics**
1.	**Discover Mechatronics**

§5 Semester modules

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<tr><td>4.</td><td colspan="15">MCCOM4
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Develop Intelligent Dynamic Mechatronic Systems</td><td colspan="10">IMDYN3M
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§6 Description of first semester

SEMESTER THEME

The theme for the first semester is 'The Mechatronic Development Process'.

VALUE ARGUMENTATION

It is important for new students to gain an insight into what mechatronics is, as well as an understanding of how the development of mechatronic products may proceed, as this will later enable them to understand and make use of the more complex concepts and skills required for the development of mechatronic products.

During the project work this semester, students will experiment with the design of a small mechatronic product and will be guided through all the phases of the development process. This will enable students to gain a general knowledge of the individual disciplines, the interdisciplinary nature of the work, and the process involved, thus providing them with an overview of what mechatronics is. The project is supported by the semester courses in mechanical design, materials and processes, and embedded systems, as well as the associated physics/mathematics.

COMPETENCE GOALS

Students will be able to:

- explain and use a structured, phased product development module for the development of a mechatronic product from idea, concept, outline, choice of materials/process through to prototype manufacture;
- design, and have manufactured, mechanical elements based in CAD;
- write software that is able to register input from the surroundings, process this and send control information back to the environment using an existing hardware platform; and
- understand the mathematical and physical basis of simple mechanical systems.

SEMESTER STRUCTURE

IMMDP1M – The Mechatronic Development Process (30 ECTS points)

The module is mandatory and constitutes the first-year examination.

CONTEXT

The semester includes one module: IMMDP1M (The Mechatronic Development Process). The module contains a semester project of the same title as the semester theme, as well as four supporting academic fields. Overall, this forms an introduction to the concept of mechatronics and its associated core skills. The four academic fields are: DES: Mechanical Design; MAP1: Materials and Processes; EMB1: Embedded Hardware/Software; and DYM: Mathematics/Physics (dynamic systems).

§7 Description of second semester

SEMESTER THEME

The theme for the second semester is 'Build Mechatronics'.

VALUE ARGUMENTATION

In relation to the development of mechatronic products, it is important for students to have both a command of the system in general and knowledge of the system components and their interaction. This semester introduces thinking about the system and builds up experience in the modelling of systems with feedback. In addition, students learn how to design electronic and mechanical elements, as well as how to manufacture and apply them. This application takes the form of a semester project in which the theme of the semester is central: the construction of a mechatronic product that can move. The project is backed up by the other academic fields of the semester, which provide an insight into the technology and the physical/mathematical foundation.

COMPETENCE GOALS

Students will be able to:

- design and have mechanical components manufactured;
- build digital electronics;
- integrate electronics, mechanics and software into an overall functioning system; and
- describe the kinematics of a system and produce simple mathematical models of systems with feedback.

SEMESTER STRUCTURE

IMBMM2M – Build Mechatronic Products that can Move (20 ECTS points)
IMBAM2M – Basic Mechatronics (10 ECTS points)

Both modules are mandatory.

CONTEXT

The semester includes two modules: IMBMM2M (Build Mechatronic Products that can Move) and IMBAM2M (Basic Mechatronics). IMBMM2M focuses particularly on the theme of the semester, as in semester project SPRO2M a mechatronic system is to be built that can move. The two associated academic fields, CYB and EMB2, provide an insight into the modelling of systems with feedback and the design of digital electronics. On the basis of the competencies attained in the first semester, students will thus be able to build a complete system. Module IMBAM2M (Basic Mechatronics) provides the background to the semester, particularly the theoretical angle in terms of the associated mechanics, mathematics and physics.

§8 Description of third semester

SEMESTER THEME

Develop Mechatronics

VALUE ARGUMENTATION

Over the first two semesters, students will have attained a fundamental knowledge of mechatronics and mechatronics development, and learned how to design mechanics and digital electronics. In this semester, it is important for students to attain a greater understanding of the whole concept and gain a more professional approach to the development of products. This is achieved by teaching students about analogue electronics, actuators and sensors, and dynamic systems. A project is completed in which students' development efforts are focused on the application of actuators and sensors, the design of electronics and the specification and production of mechanics, thus enabling the development of a complete mechatronic system. Students gain an insight into the interaction between the various skills, including the dynamic conditions within systems:

- students gain an insight into, and understanding of, the interaction between mechanics and electronics;
- students are able to understand and model dynamic problems in connection with mechatronic systems;
- students can specify, design and develop mechatronic products, in which a mechanical system is regulated by an analogue electronic system; and
- students have a command of the physics that forms the basis of selected transducers and actuators.

COMPETENCE GOALS

In the third semester, students attain the following academic competencies:

- the ability to analyse, specify and design passive and active analogue electronic circuits;
- an understanding of the physical basic principles in actuators and sensors, and an ability to use these as components in the development of mechatronic systems;
- an insight into, and understanding of, the interaction between mechanics and electronics;
- the ability to understand and model dynamic problems in connection with mechatronic systems;
- the ability to specify, design and develop mechatronic products, in which a mechanical system is regulated by an analogue electronic system that is central to the functionality; and
- the ability to integrate mechanics, electronics and software into a functioning mechatronic system.

SEMESTER STRUCTURE

IMDIM3M – Develop Intelligent Dynamic Mechatronic Systems (20 ECTS points)
IMDYN3M – Dynamic systems (10 ECTS points)

Both modules are mandatory.

CONTEXT

The semester consists of two modules, IMDIM3M (Develop Intelligent Dynamic Mechatronic Systems) and IMDYN3M (Dynamic systems). In IMDIM3M, students complete a semester project that deals with the development of an intelligent mechatronic system, in which the electronics and software must be developed, while the mechanics must be designed, specified and manufactured externally. The accompanying teaching deals in particular with the development of electronics as well as sensors and actuators. In IMDYN3M, the focus is on the theoretical aspect of dynamic systems and the modelling of electro technical systems.

§9 Description of fourth semester

SEMESTER THEME

Construct Mechatronics

VALUE ARGUMENTATION

In the fourth semester, the focus is on students being able to apply their knowledge of the development process of mechatronic products combined with the ability to construct power circuits and validate the quality of the constructed mechatronic system. The third semester is consolidated by the introduction of Power Electronics, Thermodynamics and Computer Aided Engineering, which form a significant theoretical foundation for the development of advanced mechatronic systems. Students also choose an elective course. The semester results in a general specialisation in the field of mechatronics and initiates a profiling that may continue with actual specialisation at graduate engineer level.

COMPETENCE GOALS

In the fourth semester, students attain the following academic competencies:

- the ability to model and implement a mechatronic system or product while taking into account the context of which it forms part;
- the ability to use element analysis to solve simple plane, axial and spatial structures;
- the ability to construct power electronic circuits and understand control of power circuits;
- the ability to validate solutions with respect to production quality, tolerances and life time estimates;
- theoretical ballast in thermodynamic conditions in connection with mechatronic systems; and
- Specialisation through the choice of an elective course, for instance:
    - Electromagnetic waves; or:
    - Development of object-oriented programs for embedded systems; or
    - AC and DC motors and their application as actuators.

SEMESTER STRUCTURE

MCCOM4 – Construct Mechatronics (15 ECTS points)
MCCAE4 – Computer Aided Engineering (5 ECTS points)
MCTHER4 – Thermodynamics (5 ECTS points)

The above modules are mandatory. In addition, the semester includes an elective course equivalent to 5 ECTS points.

CONTEXT

The semester consists of three mandatory modules, MCCOM4 (Construct Mechatronics), MCCAE4 (Computer Aided Engineering) and MCTHER4 (Thermodynamics). In addition, students must choose an elective course. MCCOM4 consists of a semester project in which a mechatronic product must be developed that makes use of the profile subject and the other skills learnt during the semester. The module includes teaching in main topics of power electronics. In MCCAE4 and MCTHER4, teaching is provided in Thermodynamics and Computer Aided Engineering – a necessary theoretical foundation that will support the development of advanced mechatronic products.

§10 Description of fifth semester

SEMESTER THEME

Experts in Teams

VALUE ARGUMENTATION

The purpose of the theme is as follows:

Students will gain knowledge of and the ability to develop complex mechatronic systems, including the particular focus on control systems. Students will also gain experience of the completion of project work in a context of 'innovation and enterprise'. The work of the project is organised into a virtual company, and students must complete all phases of development from the idea to the manufacture of a fully functioning prototype, taking into account finance, external suppliers, etc. In addition, the semester includes two electives, in which students can consolidate their chosen specialization from the fourth semester, and become 'experts on the team'.

COMPETENCE GOALS

In the fifth semester, students attain the following academic competencies:

- the ability to model a control system in the context of a mechatronic product;
- experience of project management, the construction of the required organisation and financial management of a project;
- knowledge of how to collaborate on a major project requiring different skills;
- the ability to understand their own roles in the work of the project;
- an understanding of the philosophical aspects of science; and
- the attainment of further specialisation through the choice of two elective courses, for example:
    - Optics and Sensor Technology;
    - Clean Room Manufacture;
    - The application of real-time operating systems;
    - The modelling of digital systems using VHDL;
    - Mechanical vibrations;

SEMESTER STRUCTURE

EXS5 – Experts in Teams and Science Theory (15 ECTS points)
MCCOE5 – Control Engineering 5 (5 ECTS points)

The above modules are mandatory. In addition, two elective or profile courses equivalent to 10 ECTS points.

CONTEXT

The semester consists of two mandatory modules, EXS5 (Experts in Teams and Science Theory) for 15 ECTS points, of which Science Theory constitutes 3 ECTS points and MCCOE5 (Control Engineering) is worth 5 ECTS points. In addition, specialisation via two elective subjects, each worth 5 ECTS points. MCCOE5 contains basic control technology. Students complete a project that includes an interdisciplinary problem. Engineering methodology forms an integral part of the project work, and particular emphasis is placed on project management, organisation and roles on the project. There is a focus on the application of the methods of research and science theory in the resolution of new problems.

§11 Description of the sixth semester

SEMESTER THEME

Internship.

Focus is put on practical training of core competencies and an advanced business understanding.

VALUE ARGUMENTATION

The students' abilities are improved by taking part in the company's projects; and thus train the acquired theory and project procedures. Co-operation and networking with industrial companies open doors for finding a final project and maybe also the first job.

COMPETENCE GOALS

To expand on the students' business understanding, develop their creativity, independence and interpersonal skills; and to provide students with more of the following competencies:

- Ability to transform the theoretical core areas of the programme into practical and feasible projects.
- Competency requiring that new knowledge is acquired to carry through projects.
- Comprehension of a company's organisational, economic, social and work-related conditions.
- Knowledge of a company's social and executive environment (communication and co-operation among employees at different level; as well as rules and clerical routines).
- Skills in presenting working results both orally and in writing; in forums of different level.

SEMESTER STRUCTURE

IMINGPR – Industrial Engineering Training (30 ECTS)

The module is mandatory.

§12 Description of the seventh semester

SEMESTER THEME

Final Project.

Focus is put on problem-based project work linked up to the principal subjects of the programme.

VALUE ARGUMENTATION

The final project must reveal an independent, experimental or theoretical discussion of a practical problem linked up to the principal subjects of the programme. The student is trained in professional problem-solving in co-operation with an internal supervisor and an external supervisor from industry.

COMPETENCE GOALS

The final project must demonstrate the student's ability to independently describe, analyse and build up solutions for practical engineering problems. The student must prove skills in: translating technical research results; and scientific and technical knowledge into practical application by means of development tasks and solving technical problems having a critical and reflective approach to experiences from the internship.

Critically acquiring new knowledge within relevant engineering areas and hereby independently solve engineering problems drawing in social, economic, environmental- and working consequences when solving technical problems attending executive- and co-operative relations with people of different educational and cultural background putting into perspective the project's results to a broader target group.

SEMESTER STRUCTURE

IMPROJ – Final Project (30 ECTS).

The module is mandatory.

§13 Entry into force and changes

1. Approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 20 August 2008.

2. Study start september 2011 approved by the Academic Study Board of the Faculty of Engineering and Director of Studies on behalf of the Dean of the Faculty of Engineering on 13th April 2012 (Version 1.0).