Chapter 9
Curriculum Syllabus for

Diplomingeniør i Mekatronik
Bachelor of Engineering in Mechatronics
Study start 2008

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Description of 1st to 7th semester including argumentation of values, competency targets and description of the individual modules.

Approved by the Academic Study Board of the Faculty of Engineering on 20 August 2008

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 in one of the profiles: 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 Competencies Provided by 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;
- specialised knowledge within either of the profiles: Nanotechnology, Embedded Systems or Dynamic Mechatronic Systems;
- the ability to carry out development projects independently and in teams;
- the potential to become project manager for product development assignments.

3 General Subject Columns

The mechatronics engineer acquires the competencies by working with subject from the five subject columns:

- the theoretical basis in mathematical/physical modelling;
- dynamics in mechatronic products – practical and theortic;
- technologies and design;
- methods and personal learning;
- specialisation.

The technical subjects are interconnected by the semester themes of the semester concerned. The student continuously acquires the requisite technical knowledge and personal competencies during the study programme. Each column includes the following subjects and disciplines:

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

Mainly comprises the units: DYM, ESY, EPHYS, THER, and CAE with the following main content:

DYM: Integration technique; differentiation technique; vector algebra; matrix algebra; absolute velocity and acceleration; coordinate systems; Newton's laws; work and energy; impulse and impulse momentum and maintaining these.

ESY: Trigonometric functions; complex numbers; differentiation and integration technique; Taylor series and L'Hôpital's rule; electrical fields; simple engines.

EPHYS: Laplace transform; Fourier transform; Z transform.

THER: theorems of thermodynamics; the energy equation; the state equation; the impulse theorem; the continuity equation; open and closed systems; circuit processes; flows in compressible and incompressible media; momentum and forces caused by flow; heat transmission.

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

<u>Dymamics in mechatronic products – practical and theoretic:</u>

Mainly comprises the units: CYB, COE1, COE2, MECH1, and MECH2 with the following main content:

CYB: Cybernetics; dynamic feedback systems; planning; estimation; applied mathematics; computer simulation; MATLAB; modelling; mechatronics.

COE1: 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.

COE2: 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.

Technologies and design:

Mainly comprises the units: DES, MAP, EMB1, EMB2, SAA, ELEC, and COM with the following main 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; 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: Numerical systems; Programming in C including: simple types of data, 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; interrupt.

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.

COM: Communication platforms, UART, USB, CAN, Ethernet, protocols, Modbus, CANOpen, TCP/IP

Methodology and Personal Learning:

Mainly comprises the units: SPRO1M, SPRO 2M, SPRO 3M, SPRO 4M and EXT5 with the following main content:

SPRO1M: The Mechatronic Development Process - An introduction to the discplines in mechatronics, coherens, interdisciplinarity and especially focussing on the development process. A mechatronic product is designed by applying the other technical knowledge gained during the semester.

SPRO2M: Build Mechatronics. The students build a mechatronic product which is able to move autonomously. The project is based on the other units of the semester..

SPRO3M: Develop Mechatronics. Focus is on the development of an intelligent and dynamic mechatronic product. Theory of Science is introduced.

SPRO4M: Mechatronics and the Environment. The semester project is based on the chosen specialisation (Nanotechnology, Dynamic Mechatronic Systems, Embedded Systems). Theory of science continues.

EXT5: Experts in Teams. The students design a product concept encompassing complex problems across academic disciplines. The project is described, presented and evaluated in English language and is carried out by students from different academic disciplines. Theory of science is completed.

Through the projects the personal and learning-related competencies are strengthened and developed, and at the same time the professional and technical competencies are learned in-depth and brought out in 'real' projects.

Personal competencies: commitment, initiative, responsibility, ethics, general education, the ability to put personal learning into perspective.
Learning related competencies: selection, collection, analysis and assessment of data, communicating results by applying modus operandi that require reflection, teamwork and independence.

Specialisation and Electives:

The competencies can be focused by choosing electives in fourth and fifth semester (15 ECTS) or by choosing one of the three specialisations: Nanotechnology, Embedded Systems or Dynamic Mechatronic Systems.

Nanotechnology.
Comprises the units: NAE, OPS and CLM with the following main content::

NAE: Basic quantum mechanics; energy gaps and confinement effects; crystal structures; bandstructure; elementary excitations; nanolayers; nanoparticles; nanostructuring; nano-architecture; nanoelectronics; nanomechanics; nanophotonics.

OPS: Optics and Photonic Sensors.

CLM: Micro fabrication techniques and processes.

Embedded Control Systems
Comprises the units: RTOS, PLD and ADP with the following main content:

RTOS: Real-time kernels and operating systems: functions and subsystems – task management, time management, event management, synchronization and communication, etc.; embedded system design using kernels

PLD: Programmable logic circuits; field-programmable gate arrays (FPGA's); hardware design languages (e.g. *VHDL*); FPGA-based hardware design tools and environments.

ADP: Advanced Programming: Inheritance, Polymorphism, Templates, Exceptions, Graphical User Interface, Interface to a SQL-database.

Dynamic Mechatronic Systems
Comprises the units: ACT, MEV and ARI with the following main content:

ACT: The main topic is the DC motor and the control of the motor which includes: Motor Physics, controller types, control of speed, torque and position, feedback systems, 1, 2 and 4 quadrant operations, energy handling. Other actuator and controller types will be studied with the DC motor as frame of reference. This includes: stepper motors, AC motors, linear motors, voice coil, piezo actuators, electro active polymers.

MEV: Vibration and time response for mechanical components; the harmonic oscillator (damped and undamped oscillations); vibrations of strings, bars, membranes, and plates; introduction to nonlinear mechanical vibrations.

ARI: : Introduction to knowledge-based intelligent systems, rule-based expert systems, uncertainty management in rule-based expert systems, fuzzy expert systems, artificial neural networks, hybrid intelligent systems

4 Semester themes

Semester	SEMESTER THEMES
7.	**Final Project**
6.	**Internship**
5.	**X-perts in teams**
4.	**Mechatronics and the Environment**
3.	**Develop Mechatronics**
2.	**Build Mechatronics**
1.	**Discover Mechatronics**

5 Semester modules

<table>
<tr><td>Semester</td><td colspan="30">STRUCTURE</td></tr>
<tr><td>7.</td><td colspan="30">Final Project</td></tr>
<tr><td>6.</td><td colspan="30">Internship</td></tr>
<tr><td>5.</td><td colspan="5">Elective or Profile</td><td colspan="5">Elective or Profile</td><td colspan="10">XIT 5
X-perts in Teams</td><td colspan="10">ADM 5M
Advanced Mechatronics</td></tr>
<tr><td>4.</td><td colspan="5">Elective or Profile</td><td colspan="10">MEN 4M
Mechatronics and the Environment</td><td colspan="15">ADM 4M
Advanced Mechatronics</td></tr>
<tr><td>3.</td><td colspan="20">DIM 3M
Develop Intelligent Dynamic Mechatronic Systems</td><td colspan="10">DYN 3M
Dynamic Systems</td></tr>
<tr><td>2.</td><td colspan="20">BMM 2M
Build Mechatronic Products that can Move</td><td colspan="10">BAM 2M
Basic Mechatronics</td></tr>
<tr><td>1.</td><td colspan="30">MDP 1M
The Mechatronic Development Process</td></tr>
<tr><td>ECTS POINT</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td></tr>
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6 Description of the first semester

Semester theme:
First semester: ”The Mechatronic Development Process”

Argumentation of values:
It is important for new students to gain an understanding of what mechatronics is and an understanding of how mechatronic products can be developed. This will enable them to understand and utilise the complex correlations between disciplines and the technical knowledge necessary for developing mechatronic products.

During the semester project the students experiment with developing a small mechatronic product and the students are led through all phases of the development process. In doing so, the student gain general knowledge about individual subjects, interdisciplinarity and process, thus gaining an overview of what mechtronics is. The project is underpinned by the semester courses in mechanical design, materials and processes, embedded systems and the supporting mathematics and physics.

Competency tagets:
The student should learn to:

- Explain and use a structured product development model divided into phases to develop a mechatronic product from idea, concept, sketching, choise of materials/process to making a prototype;
- design and have mechanical elements developed using CAD modelling;
- Develop software able to receive input from the surroundings, process the input and respond back to the surroundings using an existing hardware platform;
- Understand the mathematics and physics of simple mechanical systems.

Context:
The semester consists of one module: MDP 1M (mechatronic development process). The module includes a semester project with the same title as the semester theme, as well as four units to underpin the project. Overall, this constitutes an introduction to the concept of mechatronics and the underpinning central subject knowledge. The four units are: DES (mechanical design); MAP1 (materials and processes); EMB1 (embedded hardware/software); DYM (mathematics/physics (dynamic systems)).

7 Module descriptions for the 1st Semester

Module descriptions for B.Eng in Mechatronics, applicable for first semester students enrolled in September 2008, is available in the Course Database under Course Descriptions autumn 2008.

[NOTE: Descriptions of semesters 2 – 7 is currently being translated]

8 Description of the second semester

9 Module descriptions for the 2nd Semester

Module descriptions for B.Eng in Mechatronics, applicable for first semester students enrolled in September 2008, is available in the Course Database under Course Descriptions spring 2009.

10 Description of the third semester

11 Module descriptions for the 3rd Semester

Module descriptions for B.Eng in Mechatronics, applicable for first semester students enrolled in September 2008, is available in the Course Database under Course Descriptions autumn 2009.

12 Description of the fourth semester

13 Module descriptions for the 4th Semester

Module descriptions for B.Eng in Mechatronics, applicable for fourth semester students enrolled in September 2008, is available in the Course Database under Course Descriptions spring 2010.

14 Description of the fifth semester

15 Module descriptions for the 5th Semester

Module descriptions for B.Eng in Mechatronics, applicable for fifth semester students enrolled in September 2008, is available in the Course Database under Course Descriptions autumn 2010.

16 Description of the sixth semester

17 Module descriptions for the 6th Semester

Module descriptions for B.Eng in Mechatronics, applicable for sixth semester students enrolled in September 2008, is available in the Course Database under Course Descriptions spring 2011.

18 Description of the seventh semester

19 Module descriptions for the 7th Semester

Module descriptions for B.Eng in Mechatronics, applicable for seventh semester students enrolled in September 2008, is available in the Course Database under Course Descriptions autumn 2011.