Curriculum for the Bachelor of Science Programme in Energy

Aalborg University

September 2015

Disclaimer:
This is a translation of the Danish study curriculum of the Bachelor of Science Study Programme in Energy (Aalborg).

Any interpretation of the curriculum as well as decisions made hereupon will be based upon the Danish curriculum.
Pursuant to Act 960 of 14 August 2014 on Universities (the University Act) with subsequent changes, the following curriculum for the Bachelor of Science (BSc) programme in Energy is stipulated. The programme also follows the Joint Programme Regulations and the Examination Policies and Procedures of the Faculty of Engineering and Science.

The BSc programme in Energy is a three-year education which qualifies the students to commence the Master of Science (MSc) study programme in Energy Engineering, under the Study Board of Energy, with one of the following specialisations:

- Electrical Power Systems and High Voltage Engineering
- Fuel Cells and Hydrogen Technology
- Mechatronic Control Engineering
- Power Electronics and Drives
- Thermal Energy and Process Engineering
- Wind Power Systems

and the MSc study programme in Sustainable Energy Engineering, under the Study Board of Energy, with one of the following specialisations:

- Combustion Technology
- Offshore Energy Systems

The study programme also qualifies the students to commence other MSc study programmes at Aalborg University. Please refer to [http://www.en.aau.dk/education/master](http://www.en.aau.dk/education/master)

The programme gives a possibility to obtain advanced skills in areas as for instance efficient use of energy, renewables, control engineering and energy distribution technology.

The study programme provides wide theoretical knowledge and useful tools for solving problems in a broad field of application. For example, new energy production systems and energy optimisation of applications are studied in depth.
## Table of Contents

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preface ..........................................................................................................................</td>
</tr>
<tr>
<td>1. Legal Basis of the Curriculum ......................................................................................</td>
</tr>
<tr>
<td>1.1 Basis in Ministerial Orders ..........................................................................................</td>
</tr>
<tr>
<td>1.2 Faculty Affiliation .........................................................................................................</td>
</tr>
<tr>
<td>1.3 Study Board Affiliation .................................................................................................</td>
</tr>
<tr>
<td>2. Admission, Degree Designation, Programme Duration and Competence Profile ...............................</td>
</tr>
<tr>
<td>2.1 Admission .....................................................................................................................</td>
</tr>
<tr>
<td>2.2 Degree Designation in Danish and English ...................................................................</td>
</tr>
<tr>
<td>2.3 The Programme’s Specification in ECTS Credits ................................................................</td>
</tr>
<tr>
<td>2.4 Competence Profile on the Diploma ...............................................................................</td>
</tr>
<tr>
<td>2.5 Competence Profile of the Programme ..........................................................................</td>
</tr>
<tr>
<td>3. Content and Organisation of the Programme .....................................................................</td>
</tr>
<tr>
<td>3.1 Module Descriptions of 1st Semester ..........................................................................</td>
</tr>
<tr>
<td>3.1.a P0 Project on 1st Semester .........................................................................................</td>
</tr>
<tr>
<td>3.1.b P1 Project on 1st Semester ........................................................................................</td>
</tr>
<tr>
<td>3.1.c Course Module on 1st Semester: Calculus ..................................................................</td>
</tr>
<tr>
<td>3.1.d Course Module on 1st Semester: Fundamental Energy System Physics and Topology ........</td>
</tr>
<tr>
<td>3.1.e Course Module on 1st Semester: Problem Based Learning in Science, Technology and Society</td>
</tr>
<tr>
<td>3.2 Module Descriptions of 2nd Semester ..........................................................................</td>
</tr>
<tr>
<td>3.2.a Project on 2nd Semester ...........................................................................................</td>
</tr>
<tr>
<td>3.2.b Course Module on 2nd Semester: Introduction to Electrical Engineering ..................</td>
</tr>
<tr>
<td>3.2.c Course Module on 2nd Semester: Introduction to Mechanics and Thermodynamics .........</td>
</tr>
<tr>
<td>3.2.d Course Module on 2nd Semester: Linear Algebra ......................................................</td>
</tr>
<tr>
<td>3.3 Module Descriptions of 3rd Semester ...........................................................................</td>
</tr>
<tr>
<td>3.3.a. Project on 3rd Semester ..........................................................................................</td>
</tr>
<tr>
<td>3.3.b Course Module on 3rd Semester: AC Circuit Theory ..................................................</td>
</tr>
<tr>
<td>3.3.c Course Module on 3rd Semester: Applied Engineering Mathematics ..........................</td>
</tr>
<tr>
<td>3.3.d Course Module on 3rd Semester: Thermodynamics, Heat Transfer and Fluid Dynamics ....</td>
</tr>
<tr>
<td>3.4 Module Descriptions of 4th Semester ..........................................................................</td>
</tr>
<tr>
<td>3.4.a. Project on 4th Semester ...........................................................................................</td>
</tr>
<tr>
<td>3.4.b Course Module on 4th Semester: Fundamental Control Theory ....................................</td>
</tr>
<tr>
<td>3.4.c Course Module on 4th Semester: Mechanics ...............................................................</td>
</tr>
<tr>
<td>3.4.d Course Module on 4th Semester: Real-Time Systems and Programming Languages .......</td>
</tr>
<tr>
<td>3.5 Module Descriptions of 5th Semester .........................................................................</td>
</tr>
<tr>
<td>3.5.a. Course in Problem Based Learning and Project Management ......................................</td>
</tr>
<tr>
<td>3.5.b. Project on 5th Semester: Electrical Energy Engineering ..........................................</td>
</tr>
<tr>
<td>3.5.c Project on 5th Semester: Mechatronics .....................................................................</td>
</tr>
<tr>
<td>3.5.d Project on 5th Semester: Thermal Energy Engineering ...............................................</td>
</tr>
<tr>
<td>3.5.e Course Module on 5th Semester: Power Electronics ....................................................</td>
</tr>
<tr>
<td>3.5.f Course Module on 5th Semester: Electrical Machines ..................................................</td>
</tr>
<tr>
<td>3.5.g Course Module on 5th Semester: Modelling of Thermal Systems ...............................</td>
</tr>
<tr>
<td>3.5.h Course Module on 5th Semester: Numerical Methods .................................................</td>
</tr>
<tr>
<td>3.5.i Course Module on 5th Semester: Heat Transfer ............................................................</td>
</tr>
<tr>
<td>3.6 Module Descriptions of 6th Semester ..........................................................................</td>
</tr>
<tr>
<td>3.6.a. BSc Project on 6th Semester: Electrical Energy Engineering ....................................</td>
</tr>
<tr>
<td>3.6.b. BSc Project on 6th Semester: Mechatronics ...............................................................</td>
</tr>
<tr>
<td>3.6.c. BSc Project on 6th Semester: Thermal Energy Engineering ...........................................</td>
</tr>
<tr>
<td>3.6.e. Course Module on 6th Semester: Design and Control of Hydraulic Systems ...............</td>
</tr>
<tr>
<td>3.6.f. Course Module on 6th Semester: Electrical Power Systems .......................................</td>
</tr>
<tr>
<td>3.6.g. Course Module on 6th Semester: Chemical Thermodynamics and Process Optimisation ...</td>
</tr>
<tr>
<td>3.6.h. Course Module on 6th Semester: Flow Machines .........................................................</td>
</tr>
<tr>
<td>3.6.i. Course Module on 6th Semester: State Space and Discrete Control .............................</td>
</tr>
<tr>
<td>4. Entry into Force, Interim Provisions and Revision ................................................................</td>
</tr>
<tr>
<td>5. Other Provisions ............................................................................................................</td>
</tr>
<tr>
<td>5.1 Rules concerning Written Work, including the Bachelor’s Thesis ....................................</td>
</tr>
<tr>
<td>5.2 Rules concerning Credit Transfer (Merit), including the Possibility of Choice of Modules that are part of Another Programme at a University in Denmark or Abroad ..................................................</td>
</tr>
</tbody>
</table>
1. Legal Basis of the Curriculum

1.1 Basis in Ministerial Orders
The Bachelor’s programme in Energy is organised in accordance with the Ministry of Higher Edu-
cation and Science’s Order no. 1520 of 16 December 2013 on Bachelor’s and Master's Pro-
grammes at Universities (the Ministerial Order of the Study Programmes) and Ministerial Order no.
670 of 19 June 2014 on University Examinations (the Examination Order) with subsequent chang-
es. Further reference is made to Ministerial Order no. 257 of 18 March 2015 (the Admission Order)
and Ministerial Order no. 114 of 3 March 2015 (the Grading Scale Order) with subsequent chang-
es.

1.2 Faculty Affiliation
The Bachelor’s programme falls under the Faculty of Engineering and Science, Aalborg University.

1.3 Study Board Affiliation
The Bachelor’s programme falls under the Study Board of Energy in the School of Engineering and
Science.

1.4 External Evaluator Corps
The programme falls under the external evaluator corps: Ingeniøruddannelsernes landsdækkende
censorkorps.

2. Admission, Degree Designation, Programme Duration and Competence Profile

2.1 Admission
Admission to the Bachelor’s study programme in Energy requires a higher secondary education.
The specific entry requirements for the programme are Danish A, English B, Mathematics A, and
one of the following pair of requirements:

1. Physics B and Chemistry C
2. Physics B and Biotechnology A
3. Geoscience A and Chemistry C
cf. the Admission Order.

2.2 Degree Designation in Danish and English
The Bachelor of Science programme entitles the graduate to the designation of one of the following
titles:

- Bachelor of Science (BSc) in Engineering (Energy Engineering with specialisation in Elec-
trical Energy). The Danish designation is: Bachelor (BSc) i teknisk videnskab (energi med specialisering i elektrisk energiteknik)
- Bachelor of Science (BSc) in Engineering (Energy Engineering with specialisation in Ther-
mal Energy). The Danish designation is: Bachelor (BSc) i teknisk videnskab (energi med specialisering i termisk energiteknik)
- Bachelor of Science (BSc) in Engineering (Energy Engineering with specialisation in Mech-
atronics). The Danish designation is: Bachelor (BSc) i teknisk videnskab (energi med specialisering i mekatronik)
2.3 The Programme’s Specification in ECTS Credits

The Bachelor’s programme is a 3-year, research-based, full-time study programme. The programme 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 study programme has competences acquired through a study programme that has taken place in a research environment.

A graduate of the Bachelor’s study programme has fundamental knowledge about and insight into the methods and scientific foundation of the subjects studied. These competences qualify the graduate for further education in a relevant Master’s study programme and for employment on the basis of the study programme.

2.5 Competence Profile of the Programme

The graduate of the Bachelor’s programme has the following qualifications:

Knowledge

- Knowledge about theory, method and practice in central subject areas within thermal, electrical and mechatronic energy engineering together with its control
- Understanding of and reflection on theory, method and practice of the above mentioned energy engineering subject areas
- Knowledge about and insight into fundamental thermal, mechanical and electrical areas consisting of heat transmission, fluid flow, thermodynamics, circuit theory, electromagnetic theory, material science, electrical and thermal machines, hydraulics, statistics, mechanics of materials and vibration analysis
- Knowledge about and insight into the mathematical foundation in engineering
- Knowledge about and insight into fundamental control theory, laboratory technology and data acquisition in practice

In addition, the graduate specialised in

- **Electrical Energy Engineering** should have knowledge about and insight into fundamental power electronics, power systems and steady-state models for electrical machines
- **Mechatronics** should have knowledge about and insight into analysis and design of mechatronic systems and their control
- **Thermal Energy Engineering** should have knowledge about and insight into cooling and heating technology, combustion, thermal process design and thermal energy systems

Skills

- Be able to use up-to-date methods and tools to solve problems within thermal, electrical and mechatronic energy engineering, and also to apply these skills when employed
- Be able to evaluate theoretical and practical energy problems and also to give reasons for their choice and select a relevant solution based on set up energy engineering, mathematical, simulation and/or analysis models
- Be able to communicate academic problems and solutions to both peers and non-specialists or collaborative partners and users
- Be able to operate and control units in energy areas
- Be able to make scientific analysis based on results achieved
from models or practical measurements on energy systems

Competences

- Be able to handle complex and development-oriented situations in a study or work context
- Be able to be part of discipline-specific and interdisciplinary cooperation with a professional approach within the energy areas
- Be able to identify own learning needs and structure own learning in different learning environments
- Be able to transfer academic knowledge and skills to problem solving in practice
- At the end of the Bachelor's programme in Energy the graduate has achieved professional competences in planning, production, distribution and consumption of electrical, thermal and/or mechanical energy, together with control of energy systems. The achieved skills enable the graduate to perform design, development, consultancy and research in Danish and international companies or public institutions. Examples could be energy supply companies, wind energy, machine or process industry and electro-technical companies and consultants.

3. Content and Organisation of the Programme

The programme is structured in modules and organised as a problem based study. A module is a programme element or a group of programme 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. Examinations are defined in the curriculum.

The programme is based on a combination of academic, problem oriented and interdisciplinary approaches and organised based on the following types of instruction that combine skills and reflection:

- lectures
- class teaching
- project work
- workshops
- exercises (individually and in groups)
- teacher feedback
- professional reflection
- portfolio work
- laboratory work

The Bachelor's study programme in Energy comprises academic elements in the subject areas of thermal and electrical energy, control theory and mechatronics. The programme is common to all students of the 1st – 4th semesters, after which the programme is divided into three specialisations comprising of: Electrical Energy Engineering, Thermal Energy Engineering and Mechatronics; each specialisation with 50 ECTS elective modules on the 5th and 6th semesters. The teaching on the 5th and 6th semesters is in English due to enrolment of international guest students.

The project report of 1st to 4th semesters can be written in English if the supervisor is of foreign origin or if the students want to practice their English skills. This is assuming that all group members give their consent.
Bachelor’s Programme in Energy

1st semester

2nd semester

3rd semester

4th semester

5th semester
(specialisation)

6th semester
(specialisation)

Energy Systems of the Future

Energy Technologies

Modelling and Analysis of Simple Energy Conversion Systems

Control of Energy Conversion Systems

Electrical Energy Engineering

Thermal Energy Engineering

Mechatronics
Overview of the Study Programme
All modules are assessed through individual grading according to the 7-point grading scale or Passed/Not passed. All modules are assessed by external assessment (an external adjudicator) or by internal assessment (an internal adjudicator or no adjudicator).

Programme modules of the first four semesters

<table>
<thead>
<tr>
<th>Semester</th>
<th>Code</th>
<th>Module</th>
<th>ECTS</th>
<th>Assessment</th>
<th>Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>B1-1</td>
<td>Introduction to Technical Project Writing (P0)</td>
<td>5</td>
<td>Passed/Not passed</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>B1-2</td>
<td>Energy Systems of the Future (P1)</td>
<td>10</td>
<td>7-point grading scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>B1-3</td>
<td>Calculus</td>
<td>5</td>
<td>7-point grading scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>B1-4</td>
<td>Fundamental Energy System Physics and Topology</td>
<td>5</td>
<td>Passed/Not passed</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>B1-5</td>
<td>Problem Based Learning in Science, Technology and Society</td>
<td>5</td>
<td>Passed/Not passed</td>
<td>Internal</td>
</tr>
<tr>
<td>2nd</td>
<td>B2-1</td>
<td>Energy Technologies</td>
<td>15</td>
<td>7-point grading scale</td>
<td>External</td>
</tr>
<tr>
<td></td>
<td>B2-2</td>
<td>Introduction to Electrical Engineering</td>
<td>5</td>
<td>7-point grading scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>B2-3</td>
<td>Introduction to Mechanics and Thermodynamics</td>
<td>5</td>
<td>7-point grading scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>B2-4</td>
<td>Linear Algebra</td>
<td>5</td>
<td>7-point grading scale</td>
<td>Internal</td>
</tr>
<tr>
<td>3rd</td>
<td>B3-1</td>
<td>Modelling and Analysis of Simple Energy Conversion Systems</td>
<td>15</td>
<td>7-point grading scale</td>
<td>External</td>
</tr>
<tr>
<td></td>
<td>B3-2</td>
<td>AC Circuit Theory</td>
<td>5</td>
<td>7-point grading scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>B3-3</td>
<td>Applied Engineering Mathematics</td>
<td>5</td>
<td>7-point grading scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>B3-4</td>
<td>Thermodynamics, Heat Transfer and Fluid Dynamics</td>
<td>5</td>
<td>7-point grading scale</td>
<td>Internal</td>
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<td>4th</td>
<td>B4-1</td>
<td>Control of Energy Conversion Systems</td>
<td>10</td>
<td>7-point grading scale</td>
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<td></td>
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<td>Fundamental Control Theory</td>
<td>5</td>
<td>7-point grading scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>B4-3</td>
<td>Mechanics</td>
<td>5</td>
<td>7-point grading scale</td>
<td>Internal</td>
</tr>
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<td></td>
<td>B4-4</td>
<td>Real Time Systems and Programming Language</td>
<td>10</td>
<td>Passed/Not passed</td>
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</tr>
</tbody>
</table>

Final two semesters of BSc in Energy with specialisation in Electrical Energy Engineering

<table>
<thead>
<tr>
<th>Semester</th>
<th>Code</th>
<th>Module</th>
<th>ECTS</th>
<th>Assessment</th>
<th>Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>5th</td>
<td>B5-1</td>
<td>Design of Power Electronic Systems</td>
<td>15</td>
<td>7-point grading scale</td>
<td>External</td>
</tr>
<tr>
<td></td>
<td>B5-4</td>
<td>Power Electronics</td>
<td>5</td>
<td>7-point grading scale</td>
<td>Internal</td>
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<tr>
<td></td>
<td>B5-5</td>
<td>Electrical Machines</td>
<td>5</td>
<td>7-point grading scale</td>
<td>Internal</td>
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<tr>
<td></td>
<td>B5-7</td>
<td>Numerical Methods</td>
<td>5</td>
<td>7-point grading scale</td>
<td>Internal</td>
</tr>
<tr>
<td>6th</td>
<td>B6-1</td>
<td>BSc Project: Transmission and Conversion of Energy in Electrical Machines and Power Systems</td>
<td>15</td>
<td>7-point grading scale</td>
<td>External</td>
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<tr>
<td></td>
<td>B6-4</td>
<td>Sustainable Energy Systems: Economics, Environment, and Public Regulation</td>
<td>5</td>
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<td>Internal</td>
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<tr>
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<td>B6-6</td>
<td>Electrical Power Systems</td>
<td>5</td>
<td>7-point grading scale</td>
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</tr>
<tr>
<td></td>
<td>B6-9</td>
<td>State Space and Digital Control</td>
<td>5</td>
<td>7-point grading scale</td>
<td>Internal</td>
</tr>
</tbody>
</table>

Final two semesters of BSc in Energy with specialisation in Mechatronics

<table>
<thead>
<tr>
<th>Semester</th>
<th>Code</th>
<th>Module</th>
<th>ECTS</th>
<th>Assessment</th>
<th>Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>5th</td>
<td>B5-2</td>
<td>Analysis of a Mechatronic System</td>
<td>15</td>
<td>7-point grading scale</td>
<td>External</td>
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<tr>
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<td>B5-4</td>
<td>Power Electronics</td>
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<td>7-point grading scale</td>
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<td>B5-5</td>
<td>Electrical Machines</td>
<td>5</td>
<td>7-point grading scale</td>
<td>Internal</td>
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<td>B5-7</td>
<td>Numerical Methods</td>
<td>5</td>
<td>7-point grading scale</td>
<td>Internal</td>
</tr>
<tr>
<td>6th</td>
<td>B6-2</td>
<td>BSc Project: Design of a Mechatronic System</td>
<td>15</td>
<td>7-point grading scale</td>
<td>External</td>
</tr>
<tr>
<td></td>
<td>B6-4</td>
<td>Sustainable Energy Systems: Economics, Environment, and Public Regulation</td>
<td>5</td>
<td>Passed/Not passed</td>
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<td></td>
<td>B6-5</td>
<td>Design and Control of Hydraulic Systems</td>
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<td>7-point grading scale</td>
<td>Internal</td>
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<tr>
<td></td>
<td>B6-9</td>
<td>State Space and Digital Control</td>
<td>5</td>
<td>7-point grading scale</td>
<td>Internal</td>
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<tr>
<td>Semester</td>
<td>Code</td>
<td>Module</td>
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<td>Assessment</td>
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<tr>
<td>5th</td>
<td>B5-3</td>
<td>Design of Thermal Systems</td>
<td>15</td>
<td>7-point grading scale</td>
<td>External</td>
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<tr>
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<td>B5-6</td>
<td>Modelling of Thermal Systems</td>
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<td>7-point grading scale</td>
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<td>B5-7</td>
<td>Numerical methods</td>
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<td>B5-8</td>
<td>Heat Transfer</td>
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<tr>
<td>6th</td>
<td>B6-3</td>
<td>BSc Project: Thermo Mechanical Energy Systems</td>
<td>15</td>
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<td></td>
<td>B6-4</td>
<td>Sustainable Energy Systems: Economics, Environment, and Public Regulation</td>
<td>5</td>
<td>Passed/Not passed</td>
<td>Internal</td>
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<tr>
<td></td>
<td>B6-7</td>
<td>Chemical Thermodynamics and Process Optimisation</td>
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<td></td>
<td>B6-8</td>
<td>Flow Machines</td>
<td>5</td>
<td>7-point grading scale</td>
<td>Internal</td>
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</tbody>
</table>

Theory of science and scientific methods are included in the project modules (15 ECTS credits) as the project work is based on Problem Based Learning as a scientific method. Besides Problem Based Learning other scientific tools are taught in the course *Problem Based Learning in Science, Technology and Society.*
3.1 Module Descriptions of 1st Semester

3.1.a P0 Project on 1st Semester

Title
B1-1 Introduction to Technical Project Writing/Introduktion til teknisk rapportskrivning

Objective
After completion of the project the student should:

Knowledge
- Have knowledge about simple basic concepts in energy engineering
- Be familiar with working processes applied to project work, acquisition of knowledge and cooperation with the supervisor

Skills
- Be able to define and analyse a subject in energy engineering and analyse this subject from one or more angles of approach
- Be able to set up solutions to non-complicated energy problems based on an idea generation process
- Be able to communicate coherently the project results in a written, graphical and oral manner
- Be able to analyse personal learning process

Competences
- Be able to identify problems in energy engineering and reflect upon these in the problem based and project organised form of study
- Be able to communicate the results during the project work in a project report

Type of instruction
Project work including supervision. During the module the students write a P0 project report and a P0 process analysis, and the students participate in a P0 status seminar and in a P0 presentation seminar where the project group’s documents are discussed.

Examination format
Oral examination with internal adjudicator based on the presentation seminar and project report.

Assessment criteria
As stated in the Joint Programme Regulations.

3.1.b P1 Project on 1st Semester

Title
B1-2 Energy Systems of the Future/Fremtidens energisystemer

Objective
After completion of the project the student should:

Knowledge
- Be able to define and understand the energy engineering terms used in the project work and have a fundamental comprehension for the applied methods, theories and/or models in energy engineering
- Comprehend the design of energy systems and their models
- Have knowledge about the academic profile of energy engineering at which the study aims

Skills
- Be able to define the energy engineering and contextual terms used in a project report
- Be able to write a problem analysis and a problem formulation
- Be able to describe the applied energy theories and methods to analyse the chosen problem in relevant contexts
- Be able to create non-complicated models for the whole, or parts of, the selected energy system

**Competences**
- Be able to communicate the results achieved during the project work in a project report
- Be able to plan and reflect on own experience with project work and problem-solving by applying relevant analysis methods
- Be able to judge the project problem compared to sustainable development of energy systems
- Be able to apply methods/theories during the project work in order to analyse an energy engineering problem

**Type of instruction**
Project work including supervision, possibly supported by lectures, workshops, seminars, laboratory experiments, etc.

The project work is documented in a P1 project report. The students must participate in the P1 status seminar, elaborate a P1 process analysis and participate in the presentation seminar prior to the examination.

**Examination format**
Oral examination with internal adjudicator based on the presentation seminar and project report.

**Assessment criteria**
As stated in the Joint Programme Regulations.

**3.1.c Course Module on 1st Semester: Calculus**

**Title**
B1-3 Calculus/Calculus

**Objective**
Students who complete the module should:

**Knowledge**
- Have knowledge about definitions, results and techniques within the theory of differentiation and integration of functions of two or more variables
- Have knowledge about the trigonometric functions and their inverse functions
- Have knowledge about complex numbers, including computation rules and their representations
- Have knowledge about factorisation of polynomials over the complex numbers
- Have knowledge about the complex exponential function, its characteristics and its connection with trigonometric functions
- Have knowledge about curves in the plane (in both rectangular and polar coordinates) and spatial parameterisations, tangent vectors and curvatures of such curves
- Have knowledge about the theory of second order linear differential equations with constant coefficients

**Skills**
- Be able to visualize functions of two and three variables using graphs, level curves and level surfaces
- Be able to determine local and global extrema for functions of two and three variables
- Be able to determine surface area, volume, moment of inertia, etc. using integration theory
• Be able to approximate functions of one variable using Taylor’s formula, and to use linear approximations for functions of two or more variables
• Be able to perform arithmetic computations with complex numbers
• Be able to find the roots in the complex quadratic equation and perform factorisation of polynomials in simple cases
• Be able to solve linear second order differential equations with constant coefficients, in general, and with initial conditions
• Be able to reason through the use the concepts, results and theories in simple concrete and abstract problems

Competences
• Be able to develop and strengthen knowledge, comprehension and application within mathematical theories and methods in other subject areas
• Be able to give reasons and to argue on the basis of the given conditions using mathematical concepts from calculus

Type of instruction
Lectures with exercises

Examination format
Individual, oral or written examination in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University.

Assessment criteria
As stated in the Joint Programme Regulations.

3.1.d Course Module on 1st Semester: Fundamental Energy System Physics and Topology

Title
B1-4 Fundamental Energy System Physics and Topology/Energisystemers grundlæggende fysik og opbygning

Objective
Students who complete the module should:

Knowledge
• Have knowledge and comprehension within energy engineering concepts
• Have knowledge and comprehension within the topology of energy systems
• Have knowledge about major energy machines such as pumps, turbines, heat exchangers, electric motors and generators as well as their functions
• Have knowledge about non-complex energy engineering calculations
• Have gained knowledge about static and quasi static electric and magnetic fields, capacitance and inductance

Skills
• Be able to make fundamental energy and power calculations
• Be able to design a model of a simple energy system
• Be able to set up basic formulas for the processes in major energy machines
• Be able to make basic steady state calculations for energy systems
• Be able to analyse static and quasi static electric and magnetic fields and their propagation
• Be able to use electro physics to determine electric resistance, capacitance and inductance
• Be able to use electro physics to calculate mechanical forces induced by electric and magnetic fields
• Have competences within electric current, electric and magnetic fields, Ampère’s law, Faraday’s law, Lenz’ law, Maxwell’s equations and ferromagnetic materials

Competences
• Be able to acquire the terminology of the subject area
• Be able to identify own learning needs and structure own learning in energy engineering systems and electro physics

Type of instruction
Lectures, possibly supported by laboratory experiments and self-study, etc.

Examination format
Individual, oral examination in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University

Assessment criteria
As stated in the Joint Programme Regulations.

3.1.e Course Module on 1st Semester: Problem Based Learning in Science, Technology and Society

Title
B1-5 Problem Based Learning in Science, Technology and Society/Problembaseret læring i videnskab, teknologi og samfund

Objective
Students who complete the module should:

Knowledge
• Be able to explain fundamental teaching theories
• Be able to explain techniques to plan and manage project work
• Be able to explain different approaches to problem based learning (PBL), including the Aalborg Model based on problems related to society and/or humanistic coherence
• Be able to explain different approaches to analysis and judgement of problems and solutions related to engineering, natural and medical science, seen in a scientific, ethic and social perspective
• Be able to describe specific methods within energy engineering to perform such an analysis and assessment

Skills
• Be able to plan and manage a problem-based project work
• Be able to analyse the study group’s organisation and cooperation of the project work with regard to identification of the strong and weak sides and on this basis come up with solutions of how to improve teamwork in future groups
• Be able to reflect on the reasons for a group conflict, if any, and come up with possible solutions
• Be able to analyse and evaluate own study and learning effort to identify strong and weak sides, and from this consider the further course of study and study effort
• Be able to reflect on the applied methods in a scientific perspective
• Be able to point out relevant focus, concepts and methods to find and develop solutions considering the social and humanistic coherence in which the solution should be incorporated

Competences
• Be able to enter in a team-based project work
• Be able to document and present the project work
• Be able to reflect and develop own learning
• Be able to enter in and optimize collaborative learning processes
• Be able to reflect on the professional work in relation to the surrounding society

**Type of instruction**
The course is a mix of lectures, seminars, workshops, group sessions and self-study.

**Examination format**
The assessment is based on a written exercise handed in individually.

**Assessment criteria**
As stated in the Joint Programme Regulations.

### 3.2 Module Descriptions of 2nd Semester

#### 3.2.a Project on 2nd Semester

**Title**
B2-1 Energy Technologies/Energiteknologier

**Prerequisites**
The module is based on knowledge achieved in the project module Energy systems of the future or similar

**Objective**
After completion of the project the student should:

**Knowledge**
• Have knowledge and comprehension within the development of an energy engineering product, a machine and/or components
• Have knowledge and understanding within its functional principles and their application
• Have knowledge of how to set up a specification requirement for a product
• Understand fundamental principles of mechanics, thermodynamics, energy conversion and storage

**Skills**
• Be able to select, describe and apply relevant technical, scientific and contextual models, theories and methods to analyse and solve a chosen energy engineering problem
• Be able to solve the chosen energy engineering problem including relevant contexts and/or perspectives
• Be able to make a critical evaluation of the relevance of the gathered knowledge in relation to the project work and evaluate the applicability of the chosen models, theories and/or methods
• Be able to make a methodical and consequent evaluation of the energy engineering product technically and socially
• Be able to set up simulation models for selected parts of a product
• Be able to make practical test of the product in the laboratory or apply relevant data from other experimental work
• Be able to analyse the achieved test results or the collected data and compare these with the simulated values
• Be able to analyse and develop technical solutions in a sustainable perspective

**Competences**
• Be able to plan, manage and put the project work into perspective to consider further course of study
- Be able to make a systematic choice of methods for acquisition of knowledge in connection with problem analysis and problem-solving in an energy engineering problem

**Type of instruction**
Problem-based and project-oriented project work in groups. Documentation of applied data must be attached to the P2 project report in the form of well-structured and methodical journals. The project work is documented in a P2 project report, preparation of a P2 process analysis and participation in a presentation seminar.

**Examination format**
Oral examination with external adjudicator based on the presentation seminar and project report.

**Assessment criteria**
As stated in the Joint Programme Regulations.

### 3.2.b Course Module on 2nd Semester: Introduction to Electrical Engineering

**Title**
B2-2 Introduction to Electrical Engineering/Elektriske grundfag

**Objective**
Students who complete the module should:

**Knowledge**
- Have knowledge and understanding within resistive electrical circuits
- Have knowledge and understanding within operational amplifiers (Op-amps)
- Have knowledge and understanding within inductive and capacitive electrical circuits
- Have knowledge and understanding within electrical measurement techniques
- Have knowledge and understanding within laboratory procedures related with electrical circuits
- Have knowledge about different electrical theorems and laws

**Skills**
- Be able to analyse simple and complex electrical DC circuits
- Be able to use circuit theory to calculate currents, voltages, energies and powers in DC circuits
- Be able to use circuit reduction methods
- Be able to apply analytical methods to design operational amplifier circuits
- Be able to plan and to implement properly designed electrical circuits in laboratory in a safe and appropriate way
- Be able to use software tools in the design of electrical circuits
- Be able to use software tools for calculating different electrical signals in simple electrical circuits
- Have skills in the following specific topics:
  o Basic DC circuit theory (including energy storing components), Ohms law, units, Kirchhoff laws, circuit reductions (series and parallel), star-delta connections, dependent and independent sources, nodal and loop/mesh methods, basic and ideal operational amplifiers, Thévenin and Norton theorems, superposition, maximum power transfer, first and second order transients
  o Measurement of current, voltage, power and energy, using typical measurement instruments as voltmeter, ampere meter, wattmeter, multi-meter together with oscilloscopes
  o Measurement accuracy and calculation uncertainty
- Be able to use software for calculation of different electrical signals in simple electrical circuits
Competences
- Be able to handle simple development-oriented situations related to electric circuits and laboratory setups in study or work contexts
- Be able to independently engage in disciplinary and interdisciplinary collaboration with a professional approach in the area of basic DC circuit theory
- Be able to identify one’s own learning needs and to structure one’s own learning in basic circuit theory and electrical engineering laboratory

Type of instruction
Lectures with exercises and tests. The lectures in connection with laboratory tests are mandatory.

Examination format
Individual, 4-hour written examination in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University.

Assessment criteria
As stated in the Joint Programme Regulations.

3.2.c Course Module on 2nd Semester: Introduction to Mechanics and Thermodynamics

Title
B2-3 Introduction to Mechanics and Thermodynamics/Grundlæggende mekanik og termodynamik

Objective
Students who complete the module should:

Knowledge
- Have knowledge about Newton’s laws
- Have knowledge about static equilibrium
- Have knowledge about work and power
- Have knowledge about kinetic, potential and mechanical energy
- Have knowledge about momentum and angular momentum
- Have knowledge about rotation and rotational moment of inertia
- Have knowledge about torque
- Have knowledge about the laws of thermodynamics
- Have knowledge about ideal gases
- Have knowledge about heat, work and internal energy
- Have knowledge about thermo-dynamical material properties
- Have knowledge about the Boltzmann distribution
- Have knowledge about entropy

Skills
- Be able to solve simple problems within the subjects from which knowledge has been achieved

Competences
- Be able to apply theories and methods within mechanics and thermodynamics on simple model systems
- Be able to develop and enforce knowledge about, understanding of and application of theories and methods within mechanics and thermodynamics on other subjects
- Given certain preconditions, be able to make arguments with terms from mechanics and thermodynamics

Type of instruction
Lectures with exercises.
Examination format
Individual, written examination in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University.

Assessment criteria
As stated in the Joint Programme Regulations.

3.2.d Course Module on 2nd Semester: Linear Algebra

Title
B2-4 Linear Algebra/Lineær algebra

Objective
Students who complete the module should:

Knowledge
- Have knowledge about definitions, results and techniques in the theory of systems of linear equations
- Be able to demonstrate insight into linear transformations and their connection to matrices
- Have obtained knowledge about the computer program, MATLAB, and its application related to linear algebra
- Have acquired knowledge about simple matrix operations
- Have knowledge about invertible matrices and invertible linear transformation
- Have knowledge about the vector space $\mathbb{R}^n$ and its subspaces
- Have knowledge about linearly dependent vectors and linearly independent vectors, and the dimension and basis subspaces
- Have knowledge about the determinant of a matrix
- Have knowledge about eigenvalues and eigenvectors of matrices and their application
- Have knowledge about projections and orthonormal bases
- Have knowledge about first-order differential equations, and systems of linear differential equations

Skills
- Be able to apply theory and calculation techniques for systems of linear equations to determine solvability and determine complete solutions and their structure
- Be able to represent systems of linear equations by means of matrix equations, and vice versa
- Be able to determine and apply the reduced echelon form of a matrix
- Be able to use elementary matrices in connection with Gauss elimination and inversion of matrices
- Be able to determine linear dependence or linear independence of sets of few vectors
- Be able to determine dimension of and basis of subspaces
- Be able to determine the matrix for a given linear transformation, and vice versa
- Be able to solve simple matrix equations
- Be able to calculate the inverse of small matrices
- Be able to determine the dimension of and basis for kernel and column spaces
- Be able to calculate determinants and apply the result of this calculation
- Be able to calculate eigenvalues and eigenvectors for simple matrices
- Be able to determine whether a matrix is diagonalizable, and if so, be able to diagonalize a simple matrix
- Be able to calculate the orthogonal projection onto a subspace of $\mathbb{R}^n$
- Be able to solve separable and linear first order differential equations, in general, and with initial conditions
Competences
- Be able to develop and strengthen knowledge, comprehension and application of mathematical theories and methods in other subject areas
- Given certain pre-conditions, be able to make mathematical deductions and arguments based on concepts from linear algebra

Type of instruction
Lectures and exercises.

Examination format
Individual, oral or written examination in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University.

Assessment criteria
As stated in the Joint Programme Regulations.

3.3 Module Descriptions of 3rd Semester

3.3.a. Project on 3rd Semester

Title
B3-1 Modelling and Analysis of Simple Energy Conversion Systems/Modellering og analyse af enkle energikonverterende systemer

Prerequisites
The module is based on knowledge achieved in the project module Energy technologies or similar

Objective
After completion of the project the student should:

Knowledge
- Have knowledge about fundamental thermal, fluid mechanical and electrical theories and methods and their application and limitations
- Comprehend the function of the sub-components used
- Have knowledge and experience within laboratory work with energy conversion systems
- Comprehend scientific methods and theories in relation to the theme of the semester

Skills
- Be able to explain simple technical energy conversion processes
- Be able to apply theories and methods in the project work to model sub-components and/or the total energy conversion system
- Be able to analyse results from simulations and laboratory work under the project theme

Competences
- Have achieved an ability to translate academic knowledge and skills in basic thermal, fluid mechanical and electrical situations to a practical problem that can be processed and to which a solution can be found
- Have achieved an ability to engage in disciplinary and interdisciplinary field of electrical, fluid mechanical and thermal engineering

Type of instruction
Problem-based and project-oriented project work in groups.
Examination format
Oral examination with external adjudicator based on a presentation seminar and project report.

Assessment criteria
As stated in the Joint Programme Regulations.

3.3.b Course Module on 3rd Semester: AC Circuit Theory

Title
B3-2 AC Circuit Theory/AC-kredsløbsteori

Prerequisites
The module is based on knowledge achieved in the module Introduction to electrical engineering or similar

Objective
Students who complete the module should:

**Knowledge**
- Have an understanding of:
  - Basic steady-state analysis of AC circuits
  - Basic steady-state power analysis of AC circuits
  - The concepts of mutual inductance, coupling coefficients, the ideal transformer and turns ratio
  - Characteristics for balanced three phase circuits
  - Basic three-phase star and delta-connections
  - Variable frequency behaviour for basic R, L and C circuits
  - Characteristics of basic filters: Low pass, high pass, band pass and band stop
  - Various types of circuit functions
  - Definition of poles and zeros
  - Laplace domain representation of basic circuit elements (including initial conditions): R, L and C
  - Characteristics of diodes and passive single-phase and three-phase rectifiers
  - Fourier techniques for circuit analysis

**Skills**
- Be able to perform calculations of currents and voltages in steady-state AC circuits
- Be able to perform steady-state power analysis of AC circuits
- Be able to perform calculations on magnetically coupled circuits
- Be able to calculate voltages, currents, powers and power factors in three-phase circuits
- Be able to perform Bode plot and frequency analysis for variable-frequency circuits
- Be able to perform circuit analysis using Laplace transformation
- Be able to design single phase and three phase diode rectifiers
- Be able to perform Fourier analysis of periodic signals in electrical circuits

**Competences**
- Be able to handle simple development-oriented situations in connection with technical issues of AC circuits in study or work relations
- Be able to perform laboratory work and analyse the results of AC circuit in study and work relations

**Type of instruction**
Lectures with exercises and laboratory tests.
Examination format
Individual, 4-hour written examination in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University.

Assessment criteria
As stated in the Joint Programme Regulations.

3.3.c Course Module on 3rd Semester: Applied Engineering Mathematics

Title
B3-3 Applied Engineering Mathematics/Anvendt ingeniørmatematik

Prerequisites
The module is based on knowledge achieved in the modules Calculus and Linear algebra or similar

Objective
Students who complete the module should:

Knowledge
- Have knowledge about fundamental methods in vector analysis in the 2 and 3 dimensional space, and have knowledge about applications of the theory to engineering
- Have knowledge about the Laplace transform and how to apply it to solve differential equations exemplified by problems from e.g. mechanics, electronics or heat transfer
- Have knowledge about complex analytic functions
- Have an understanding of power series and Taylor series
- Have an understanding of how complex analytic functions and power series can be applied to study physical systems

Skills
- Be able to use vector calculus, within the topics:
  o Inner product (dot product)
  o Vector product (cross-product)
  o Vector and scalar functions and vector fields
  o Space curves, tangents and arc length
  o Vector differential calculation: Gradient, divergence, curl
  o Vector integral calculation: Line integrals, path independence of line integrals, double integrals, Green's theorem in the plane, and surface integrals
- Be able to apply the theory of Fourier series, within the topics:
  o Fourier series and trigonometric series
  o Periodic functions
  o Even and odd functions
  o Complex Fourier Series
- Be able to apply the theory of Laplace transformations, within the topics:
  o Definition of the Laplace transformation. Inverse transformation. Linearity and s-translation
  o Transformation of elementary functions, including periodic, impulse and step functions
  o Transformation of derivatives and integrals
  o Solution of differential equations
  o Convolution and integral equations
  o Differentiation and integration of transformed systems of ordinary differential equations
- Be able to apply complex analytical functions to conformal mapping and complex integrals within the topics:
  - Complex numbers and the complex plane
  - Polar form of complex numbers
  - Exponential functions
  - Trigonometric and hyperbolic functions
  - Logarithmic functions and general power functions
  - Complex integration: Line integrals in the complex plane
  - Cauchy's integral theorem

Competences
- Be able to use vector calculus, series, Laplace transforms and complex analytic functions to solve fundamental engineering problems.

Type of instruction
The teaching is organised according to the general teaching methods of the study programme, see chapter 3.

Examination format
Individual, 4-hour written examination in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University.

Assessment criteria
As stated in the Joint Programme Regulations.

3.3.d Course Module on 3rd Semester: Thermodynamics, Heat Transfer and Fluid Dynamics

Title
B3-4 Thermodynamics, Heat Transfer and Fluid Dynamics/Termodynamik, varmetransmission og strømningslære

Prerequisites
The module is based on knowledge achieved in the module Introduction to mechanics and thermodynamics or similar

Objective
Students who complete the module should:

Knowledge
- Have knowledge about engineering thermodynamics, fundamental fluid flow and convective heat transfer
- Have knowledge of heat conduction in terms of a thermal resistance network
- Comprehend
  - Applied thermodynamics
  - Basic fluid flow
  - Basic convection
  - Heat conduction expressed as a thermal resistance network
  - Heat exchangers or cooling of electronic components

Skills
- Be able to apply thermodynamics to solve practical problems in engineering applications
- Be able to apply the energy equation on flows in tubes and components
- Be able to apply simple fluid flow theory to analyse the fluid mechanical effects on objects surrounded by a fluid in motion
- Be able to calculate heat transfer in thermal resistance networks
- Be able to calculate convective heat transfer for both external and internal flows
Competences
- Be able to apply the subject area in interdisciplinary collaboration with other subject areas
- Be able to communicate the problem and solution to people without in-depth knowledge of the subject
- Be able to interpret results and present main conclusions

Type of instruction
Lectures supported by self-study and/or study circles.

Examination format
Individual, written examination in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University.

Assessment criteria
As stated in the Joint Programme Regulations.

3.4 Module Descriptions of 4th Semester

3.4.a. Project on 4th Semester

Title
B4-1 Control of Energy Conversion Systems/Regulering af energiomsættende systemer

Prerequisites
The module is based on knowledge achieved in the project module Modelling and analysis of simple energy conversion systems or similar

Objective
After completion of the project the student should:

Knowledge
- Have knowledge about modelling of fundamental mechanical, electrical and/or thermal systems
- Have obtained comprehension of classic fundamental control theory
- Have knowledge and experience within laboratory work on control of an energy conversion system

Skills
- Be able to set up dynamic models of an energy conversion system and be able to implement these models in a simulation tool
- Be able to set up specifications for a control system taking the system characteristics and limitations into account
- Be able to apply fundamental control theory to design and dimension a controller and evaluate its applicability
- Have knowledge about practical implementation of a controller and have understanding of the instrumentation for measuring the system conditions
- Be able to evaluate gained theoretical results and results from experiments based on laboratory work

Competences
- Be able to translate the academic knowledge and skills within fundamental classic control theory to practical problems
• Be able to engage in disciplinary and interdisciplinary cooperation within the energy control theory area related to energy systems

Type of instruction
Project based, project oriented project work in groups.

Examination format
Oral examination with internal adjudicator based on a presentation seminar and project report.

Assessment criteria
As stated in the Joint Programme Regulations.

3.4.b Course Module on 4th Semester: Fundamental Control Theory

Title
B4-2 Fundamental Control Theory/Grundlæggende regulering

Prerequisites
The module is based on knowledge achieved in the modules Calculus, Linear algebra and Applied engineering mathematics or similar

Objective
Students who complete the module should:

Knowledge
• Have knowledge about modelling of physical systems and their dynamics
• Have knowledge about methods for linearisation of non-linear systems
• Have understanding for steady state and transient response of a system, including system order and type and the influence of placement of poles and zeros
• Have understanding of the terms open loop and closed loop
• Be able to understand the frequency response of a system
• Have understanding of absolute and relative stability and methods for analysing the stability of a system
• Have understanding of root locus analysis and knowledge about designing controllers based on root locus techniques
• Have understanding of controller development and design based on frequency response approaches
• Have knowledge about practical implementation of controllers

Skills
• Be able to model and analyse simple dynamical systems (electrical, mechanical and thermal) and understand the analogy between these
• Be able to set up linear models of dynamical systems using block diagrams and transfer functions
• Be able to use elements from control theory to specify performance criteria
• Be able to analyse a systems response and stability using linear methods
• Be able to select suited controllers and predict/evaluate their influence on a given systems response
• Be able to dimension a linear controller for a given system so performance requirements are met
• Be able to judge the problem at hand and the used solution method as well as disseminate results for a technical audience

Competences
• Be able to handle development oriented situations in relation to fundamental control theory and modelling
• Independently be able to participate in professional and multidisciplinary collaboration with a professional approach with regard to fundamental control theory
• Be able to identify own learning needs and structure own learning with regard to fundamental control theory

**Type of instruction**
The teaching is organised according to the general teaching methods of the study programme, see chapter 3.

**Examination format**
Individual, written examination in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University.

**Assessment criteria**
As stated in the Joint Programme Regulations.

**3.4.c Course Module on 4th Semester: Mechanics**

**Title**
B4-3 Mechanics/Mekanik

**Prerequisites**
The module is based on knowledge achieved in the module Introduction to mechanics and thermodynamics or similar

**Objective**
Students who complete the module should:

**Knowledge**
• Have an understanding of concepts such as force, moment and static equilibrium
• Have an understanding of the area moments of inertia and mass moments of inertia
• Have an understanding of the kinematics of rigid bodies
• Have an understanding of the kinetics of rigid bodies and systems of bodies in planar motion
• Have knowledge about 3D kinetics of rigid bodies
• Have an understanding of basic solid mechanics, including strain, stress and torsion
• Have understanding of the stresses in homogeneous beams, rods and shafts, including stress distribution in tension/compression, torsion and bending
• Have knowledge about the deflections of beams under loading

**Skills**
• Be able to select appropriate supports/end fixings for analysis of mechanical systems and their components
• Be able to analyse rigid planar mechanical structures, both statically and dynamically
• Be able to determine the area moments of inertia and mass moments of inertia of selected elements
• Be able to describe the forces and their action on rigid bodies in 3D
• Be able to analyse strains and stresses in elastic beams under various loading conditions
• Be able to analyse basic cases of deflections of beams

**Competences**
• Be able to use the acquired skills to the development and analysis of models of mechanical systems
• Be able to use the professional approach to analysis of mechanical systems in academic and interdisciplinary collaboration
• Be able to identify their own learning needs and to structure own learning in mechanical engineering

**Type of instruction**
The teaching is organised according to the general teaching methods of the study programme, see chapter 3.

**Examination format**
Individual, written examination in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University.

**Assessment criteria**
As stated in the Joint Programme Regulations.

**3.4.d Course Module on 4th Semester: Real-Time Systems and Programming Languages**

**Title**
B4-4 Real-Time Systems and Programming Language/Realtidssystemer og programmeringssprog

**Prerequisites**
The module is based on knowledge achieved in the module Applied engineering mathematics or similar

**Objective:**
Students who complete the module should:

**Knowledge**
• Have knowledge about number systems (decimal, binary, hexadecimal), basic arithmetic operations and representation of fixed and floating point numbers
• Have knowledge about basic logic gates and simple combinational circuits
• Have basic knowledge about bi-stable components (flip-flops) and their use in simple clocked sequential circuits
• Have an understanding of how digital signals are represented by different electrical logic families including their static and dynamic electrical behaviour
• Have knowledge about general programming methodologies and understand the program development process from problem formulation to final implementation
• Have knowledge about the C programming language syntax including memory management, data types and variables, control structures, functions, and the use of pointers
• Have basic knowledge about the C language pre-processor, compile and linker process including the use of multiple source files and libraries
• Have knowledge about the use of an integrated development environment for C language programming and debugging
• Have a basic understanding about microcontrollers, their architecture and their use in real-time systems
• Have knowledge about fundamental microcontrollers peripheral units such as digital input/output ports and analog input/output ports
• Have knowledge about the operating principles for digital to analog converters and analog to digital converters including their use in practical microcontroller designs
• Have knowledge about special peripheral units including pulse-width modulation and quadrature encoder interface
• Have knowledge about C-programming debugging of real-time microcontroller applications with both low-priority background tasks and interrupt service routines
• Have knowledge about implementation of discrete-time filters, controllers and pulse-width modulators
• Have knowledge about graphical programming techniques
• Have knowledge about dataflow programming techniques using basic data types and control structures for both non-deterministic and real-time applications
• Have knowledge about the use of an integrated development environment for graphical programming and debugging
• Have knowledge about hardware solutions for data acquisition systems

Skills
• Be able to analyse, design and realize simple combinatorial and sequential logic circuits
• Be able to outline the main electrical characteristics of logic families and understand when interfacing circuitry is needed
• Be able to interface microcontroller digital and analog peripherals to external circuits (actuators, sensors, etc.) by taking relevant electrical characteristics into account
• Be able to select a suitable real-time system and programming environment for a particular engineering task
• Be able to divide a programming task into smaller modules that can be programmed and debugged individually
• Be able to develop and test applications using C programming and graphical programming that solve a specific task that may require real-time behaviour
• Be able to plan, execute and document laboratory experiments that involve a microcontroller-based real-time system with both analog and digital inputs and outputs

Competences
• Independently be able to conduct basic design and development within the area of real-time systems and their programming
• Independently be able to extent knowledge and competences within the topic beyond the contents of this course module

Type of instruction
The course is a mix of lectures, workshops, exercises, self-study and mini project.

Examination format
Attendance by at least 80% attendance and approval of mini project that can be completed in groups; scope of approximately 10 pages (maximum of 2800 characters per page).

Assessment criteria
As stated in the Joint Programme Regulations.

3.5 Module Descriptions of 5th Semester
3.5.a. Course in Problem Based Learning and Project Management

Title
Course in Problem Based Learning and Project Management/Projektbaseret læring og projektledelse/

Prerequisites
None, but the course is compulsory for students not acquainted to the Aalborg PBL model

Objective
The objective is to prepare newly started Master’s students from another university than AAU to enter the Problem Based Learning environment at AAU and manage study projects in close collaboration with peers.

Students who complete the module should:
Day 1
- Describe and discuss the Aalborg PBL Model based on the three key words: Group work, project work, problem orientation
- Identify an initial individual challenge when using a PBL approach

Day 2
- Develop and practice peer feedback skills
- Practice collaborative learning in a group
- Design a plan of action to deal with an initial individual PBL challenge or curiosity

Day 3
- Practice presentation skills
- Practice critical skills when giving feedback to peers
- Reflect on own and peer skills in relation to PBL practice

Type of instruction
Three-half-day workshops centred on the individual student working with an individual challenge or curiosity in relation to using a PBL approach. Peer learning is also a hallmark, since the students will discuss and reflect on their individual challenges or curiosities in a peer learning group.

Form of examination
Internal assessment during the course/class participation according to the rules in the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of Faculty of Engineering and Science, Aalborg University. In this case the assessment is primarily based on the oral performance during the course, this means that the student has to be active during the course time and participate in discussions. The course is an integrated part of the project for those not acquainted to the Aalborg PBL Model, and is a condition for participation in the project examination. In this way there will be no diploma for the course and it will not be visible on the academic transcripts.

Evaluation criteria
Passed/not passed as stated in the Joint Programme Regulations.

3.5.b. Project on 5th Semester: Electrical Energy Engineering

Title
B5-1 Design of Power Electronic Systems/Design af effektelektroniske apparater

Prerequisites
The module is based on knowledge achieved in the project module Control of energy converting systems or similar

Objective
After completion of the project the student should:

Knowledge
- Be able to understand the function of power electronic appliances
- Understand the operation, characteristics and usage of modern power electronic semiconductor components
- Be able to understand scientific methods and theories compared to the semester theme
- Be able to understand and create a business case for the power electronic device or system

Skills
- Be able to analyse and design power electronic devices with associated analog or microprocessor based controllers
- Be able to analyse power electronic interaction and impact on the environment, e.g. in drive systems with electrical machines or in relation to the impact of the electricity grid
- Have experience in building and testing of power electronic equipment via laboratory work
- Be able to make a cost-benefit analysis of the power electronic system

**Competences**
- Have achieved an ability to convert academic knowledge and skills in the field of power electronic devices for a practical problem and to process such a problem
- Have achieved an ability to enter into a technical and interdisciplinary cooperation in power electronic devices
- Be able to evaluate the basic economic conditions for the development and commissioning of systems or devices

**Type of instruction**
Problem-based and project-oriented work in project groups.

Some lectures are given in business economy to support the objectives in this area. Teaching is in English and/or Danish depending on the participation of international students, or if the supervisor is of foreign origin.

**Examination format**
Oral examination with external adjudicator based on a presentation of the project report in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem Based Learning and Project Management prior to the project examination, see section 3.5.a.

**Assessment criteria**
As stated in the Joint Programme Regulations.

**3.5.c Project on 5th Semester: Mechatronics**

**Title**
B5-2 Analysis of a Mechatronic System/Analyse af et mekatronisk system

**Prerequisites**
The module is based on knowledge achieved in the project module Control of energy converting systems or similar

**Objective**
After completion of the project the student should:

**Knowledge**
- Have knowledge about and understanding for the significance of modelling mechatronic systems
- Be able to understand the importance of control engineering as an integrated part of mechatronic design
- Have knowledge about design choices and the interaction of technologies in a mechatronic system
- Be able to understand scientific methods and theories compared to the semester theme
- Be able to understand how to set up a business case for the mechatronic system

**Skills**
- Be able to analyse the relevant dynamic interactions in a mechatronic system
• Be able to set up and apply models, to be able to conduct analyses of mechatronic, electrical, thermal, electro-mechanical and other multi-disciplinary systems
• Have gained experience with experimental validation of models for a mechatronic system
• Be able to analyse obtained results from simulations and laboratory work
• Be able to conduct a cost-benefit analysis for the mechatronic system

Competences
• Have achieved an ability to convert academic knowledge and skills of the analysis of a mechatronic system to a practical problem and be able to work on such a problem
• Have achieved an ability to enter into professional and interdisciplinary collaboration within mechatronic systems
• Be able to evaluate the basic economic conditions for the development and commissioning of systems or devices

Type of instruction
Problem-based and project-oriented work in project groups.

Some lectures are given in business economy to support the objectives in this area. Teaching is in English and/or Danish depending on the participation of international students, or if the supervisor is of foreign origin.

Examination format
Oral examination with external adjudicator based on a presentation of the project report in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem Based Learning and Project Management prior to the project examination, see section 3.5.a.

Assessment criteria
As stated in the Joint Programme Regulations.

3.5.d Project on 5th Semester: Thermal Energy Engineering

Title
B5-3 Design of Thermal Systems/Design af termiske systemer

Prerequisites
The module is based on knowledge achieved in the project module Control of energy converting systems or similar

Objective
After completion of the project the student should:

Knowledge
• Have knowledge about mode of operation of thermal machines and systems
• Have knowledge about methods for design of thermal energy systems
• Have knowledge about interaction of components included in thermal machines and energy systems
• Be able to comprehend scientific methods and theories compared to the semester theme
• Be able to set up a business case for thermal machines and systems

Skills
• Be able to develop and apply stationary models of thermal systems in full load and partial load
• Have fundamental skills in design of optimal system configurations and determination of operation parameters for thermal systems
• Be able to analyse achieved results from simulations and laboratory work, if any, and collect them to form an overall impression of the system performance
• Be able to make a cost-benefit analysis of the thermal machines or systems

**Competences**

• Have achieved an ability to convert academic competences and skills of thermal systems for processing of a practical problem
• Have achieved an ability to enter into a technical and interdisciplinary cooperation in respect to thermal systems
• Be able to evaluate the basic economic conditions for the development and commissioning of systems or devices

**Type of instruction**

Problem-based and project-oriented work in project groups.

Some lectures are given in business economy to support the objectives in this area. Teaching is in English and/or Danish depending on the participation of international students, or if the supervisor is of foreign origin.

**Examination format**

Oral examination with external adjudicator based on a presentation of the project report in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem Based Learning and Project Management prior to the project examination, see section 3.5.a.

**Assessment criteria**

As stated in the Joint Programme Regulations.

3.5.e Course Module on 5th Semester: Power Electronics

**Title**

B5-4 Power Electronics/Effektelektronik

**Prerequisites**

The module is based on knowledge achieved in the modules Introduction to electrical engineering and AC circuit theory or similar

**Objective**

Students who complete the module should:

**Knowledge**

• Have knowledge about theories applied to gain an efficient energy conversion using power electronic systems and apparatus
• Have knowledge about function and operation of power electronic components
• Have knowledge about and understanding of how power electronic systems, appliances and components are modelled
• Have knowledge about modelling tools

**Skills**

• Be able to apply knowledge about energy efficient power electronic systems, apparatus and their components for simulation
• Be able to evaluate the result of the modelling; to which extent it is representative for the physical world
• Be able to relate to models at different levels of abstraction and their applications

**Competences**
• Be able to apply academic knowledge and skills in the analysis of efficient power electronic systems, apparatus and their components to a practical problem and to process such a problem
• Be able to engage in disciplinary and interdisciplinary cooperation within power electronic systems

**Type of instruction**
The teaching is organised according to the general teaching methods of the study programme, see chapter 3. Teaching is in English and/or Danish depending on the participation of international students, or if the supervisor is of foreign origin.

**Examination format**
Individual, written examination in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University.

**Assessment criteria**
As stated in the Joint Programme Regulations.

**3.5.f Course Module on 5th Semester: Electrical Machines**

**Title**
B5-5 Electrical Machines/Elektriske maskiner

**Prerequisites**
The module is based on knowledge achieved in the modules Linear algebra, Calculus, Applied engineering mathematics and AC circuit theory or similar

**Objective**
Students who complete the module should:

**Knowledge**
• Have basic knowledge about electromagnetic phenomenon, operation and construction of transformers and electrical machines
• Know about flux, flux linkage, phase inductance, mutual inductance and their characteristics
• Have basic knowledge about electromechanical energy conversion
• Have knowledge about three-phase windings and rotating magnetic fields
• Have knowledge about electrical machine material and their characteristics as well as practical application issues, and electrical machine standards
• Have knowledge about transformers, DC, AC and synchronous machines, and the determination of their parameters by tests and construction of steady-state equivalent circuit models under various operating conditions

**Skills**
• Be able to perform calculations using equivalent circuit models for transformers and electrical machines
• Be able to make necessary simplifications of the transformer equivalent circuit diagram in different applications
• Can draw phasor diagrams for the transformer and electrical machines
• Be able to calculate the power, torque, speed, current, power factor and efficiency of transformers and electrical machines
• Be able to perform experimental tests to determine the desired parameters for transformers and electrical machines

**Competences**
- Be able to use equivalent circuit diagrams for transformers, synchronous machines, induction machines and analyse their performances under different operating conditions
- Be able to perform laboratory measurements to determine the desired parameters for equivalent circuit diagrams and models
- Be able to handle development specific situations related to the steady-state design, analysis and application of transformers and electrical machines

**Type of instruction**
Lectures, exercises and laboratory experiments. Teaching is in English and/or Danish depending on the participation of international students, or if the supervisor is of foreign origin.

**Examination format**
Individual, 4-hour written examination in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University.

**Assessment criteria**
As stated in the Joint Programme Regulations.

3.5.g Course Module on 5th Semester: Modelling of Thermal Systems

**Title**
B5-6 Modelling of Thermal Systems/Modellering af termiske systemer

**Prerequisites**
The module is based on knowledge achieved in the modules Fundamental energy system physics and topology and Thermodynamics, heat transfer and fluid dynamics or similar

**Objective**
Students who complete the module should:

**Knowledge**
- Have knowledge about stationary modelling of general thermal cycles and energy systems
- Be able to understand the topology of thermal cycles

**Skills**
- Be able to use the general theory regarding systematic formulation of conservation equations for simulation of thermal systems and thermal system components
- Be able to evaluate operational parameters in thermal systems operating in steady state
- Be able to design and simulate thermal systems
- Be able to estimate thermal and calorimetric properties in thermal systems

**Competences**
- Have the ability to use the topic in interdisciplinary collaboration with other fields of research
- Be able to evaluate the best suited methods of analysis in relation to simulation of thermal systems and be able to design and simulate thermal systems
- Be able to analyse the result of simulations of thermal systems

**Type of instruction**
Lectures supplemented with self-study and/or study circles. Teaching is in English and/or Danish depending on the participation of international students, or if the supervisor is of foreign origin.
Examination format
Oral examination in accordance with the rules in the Examination Policies and Procedures.

Assessment criteria
As stated in the Joint Programme Regulations.

3.5.h Course Module on 5th Semester: Numerical Methods

Title
B5-7 Numerical Methods/Numeriske metoder

Prerequisites
The module is based on knowledge achieved in the module Applied engineering mathematics or similar

Objective
Students who complete the module should:

Knowledge
• Comprehend the solution of partial differential equations with analytical methods
• Comprehend different numerical methods
• Comprehend finite difference, finite volume and the Finite Element Method

Skills
• Be able to use analytical methods for solving partial differential equations, including:
  o Separation Method and D'Alembert's principle
• Be able to apply numerical methods for solving mathematical problems, including:
  o Linear equations
  o Gauss elimination
  o Factorization methods
  o Iterative solution of linear equation systems, including Gauss-Seidel
  o Ill-conditioned linear equation systems
  o Matrix eigenvalue problems
  o Solution of non-linear equations
  o Interpolation
  o Splines
  o Numerical solution of a definite integral
  o Numerical solution of first order differential equations
  o Numerical solution of second order differential equations
• Be able to apply the finite difference method for solving partial differential equations, including:
  o Difference approximations
  o Elliptic equations
  o Dirichlet and Neumann boundary conditions
  o Parabolic equations
  o Explicit and implicit methods
  o Theta method
  o Hyperbolic equations
  o The use of the Finite Volume Method
• Be able to understand the Finite Element Method for the solution of partial differential equations

Competences
• Be able to handle development-oriented environments involving numerical methods in study or work contexts
• Be able to independently engage in disciplinary and interdisciplinary collaboration with a professional approach within mathematical numerical methods
Be able to identify own learning needs and to structure own learning in numerical methods

**Type of instruction**
Lectures and exercises. Teaching is in English and/or Danish depending on the participation of international students, or if the supervisor is of foreign origin.

**Examination format**
Individual, oral examination with internal adjudicator in accordance with the rules of the Examination Policies and Procedures.

**Assessment criteria**
As stated in the Joint Programme Regulations.

### 3.5.i Course Module on 5th Semester: Heat Transfer

**Title**
B5-8 Heat Transfer/Varmetransmission

**Prerequisites**
The module is based on knowledge achieved in the modules Introduction to mechanics and thermodynamics and Thermodynamics, heat transfer and fluid dynamics or similar

**Objective**
Students who complete the module should:

**Knowledge**
- Have knowledge about classical heat transfer including natural convection, forced convection and radiation
- Have knowledge about condensing, evaporation and boiling
- Be able to understand the governing mechanisms in the abovementioned processes
- Have an understanding of heat exchanger or cooling of electronic equipment

**Skills**
- Be able to use fundamental heat conduction, transient heat conduction or numerical heat conduction in analysis and design of a thermal problem
- Be able to calculate heat flux, stationary as well as transient, in multiple dimensions and complex geometries
- Be able to dimension heat transfer processes considering thermomechanical effects

**Competences**
- Have the ability to use the topic in interdisciplinary collaboration with other fields of research
- Be able to select the best method of analysis for a heat transfer problem including the quality of the found solution
- Be able to present the problem and the used method of solution to persons unfamiliar with the topic
- Be able to interpret the result and present the overall conclusions

**Type of instruction**
Lectures supplemented with self-study and/or study circles. Teaching is in English and/or Danish depending on the participation of international students, or if the supervisor is of foreign origin.

**Examination format**
Oral examination based on a mini project in accordance with the rules in the Examination Policies and Procedures.
Assessment criteria
As stated in the Joint Programme Regulations.

3.6 Module Descriptions of 6th Semester

3.6.a. BSc Project on 6th Semester: Electrical Energy Engineering

Title
B6-1 BSc Project: Transmission and Conversion of Energy in Electrical Machines and Power Systems/Bachelorprojekt: Overføring og konvertering af energi i elektriske maskiner og anlæg

Prerequisites
The module is based on knowledge achieved in the project module Design of power electronic systems or similar

Objective
After completion of the project the student should:

Knowledge
- Understand the structure and function of electrical machines and/or electric power systems, and be able to analyse these under stationary conditions and in the context of power electronic devices or systems where applicable
- Be able to understand scientific methods and theories compared to the semester theme

Skills
- Be able to analyse various models and features for electrical machines or power systems and perform calculations and model these under stationary conditions
- Have experience in laboratory work on electrical machines or power systems
- Be able to analyse results from simulations and laboratory work, and assemble them to give an overall impression of the system's performance

Competences
- Be able to handle complex and development-oriented situations in study or work contexts within energy engineering, with particular emphasis on electric energy technology, including transfer and conversion of energy in electrical machines and/or power systems
- Have the ability to enter into professional and interdisciplinary collaboration with a professional approach in the field of energy engineering
- Be able to identify own learning needs and structure learning in different environments in energy engineering
- Be able to translate academic knowledge and skills in the field of electrical energy technology to a practical problem

Type of instruction
Problem based and project oriented work in project groups.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem Based Learning and Project Management prior to the project examination, see section 3.5.a.

Teaching is in English and/or Danish depending on the participation of international students, or if the lecturer is of foreign origin.
Examination format
Oral examination with external adjudicator based on a presentation of the project report in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University.

Assessment criteria
As stated in the Joint Programme Regulations.

3.6.b. BSc Project on 6th Semester: Mechatronics

Tema:
B6-2 BSc Project: Design of a Mechatronic System/Bachelorprojekt: Design af et mechatronisk system

Prerequisites
The module is based on knowledge achieved in the project module Analysis of a mechatronic system or similar

Objective
After completion of the project the student should:

Knowledge
- Have knowledge about model-based design of a mechatronic system
- Have knowledge about how the control design is a central and integrated part of the development process for a mechatronic system
- Have knowledge about scientific methods and theories compared to the semester theme

Skills
- Be able to conduct synthesis and design of (fundamental) mechatronic systems and components and assess the applicability of different solution concepts
- Be able to analyse the interactions and limitations of different technologies in the design process
- Have acquired experience with experimental work supporting the design of a mechatronic system
- Be able to analyse and assess obtained results from simulations and experiments

Competences
- Be able to handle complex and development-oriented situations related to studies and work within the energy technical area, with special emphasis on mechatronic systems
- Have acquired the ability to professionally enter into interdisciplinary collaboration in the area of energy technology
- Be able to identify own learning needs and structure learning in different environments in energy engineering
- Be able to transform academic knowledge and skills in design of mechatronic systems to a practical problem and process the problem

Type of instruction
Problem based and project oriented work in project groups.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem Based Learning and Project Management prior to the project examination, see section 3.5.a.

Teaching is in English and/or Danish depending on the participation of international students, or if the lecturer is of foreign origin.
Examination format
Individual, oral examination with external adjudicator in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University.

Assessment criteria
As stated in the Joint Programme Regulations.

3.6.c. BSc Project on 6th Semester: Thermal Energy Engineering

Title
B6-3 BSc Project: Thermo Mechanical Energy Systems/Bachelorprojekt: Termomekaniske energisystemer

Prerequisites
The module is based on knowledge achieved in the project module Design of thermal systems

Objective
After completion of the project the student should:

Knowledge
- Have knowledge about the structure of flow machinery and other thermal flow system components used in thermal energy systems
- Have knowledge about the thermomechanical limitations due to dynamic effects of these systems
- Be able to understand scientific methods and theories in relation to the theme of the semester
- Have knowledge about the environmental conditions related to these technologies

Skills
- Be able to perform analyses related to thermal flow systems and flow system components
- Have attained experience with laboratory work with flow machinery and flow system components
- Be able to analyse and evaluate the found results from simulations and laboratory work related to flow machinery and flow system components

Competences
- Be able to handle complex development oriented situations in study and work situations within the energy technical area with particular focus on thermal systems
- Have the ability to take part in professional and interdisciplinary work with a professional approach within the energy technical area
- Be able to identify own learning needs and structure learning in different environments in energy engineering
- Have attained the ability to transfer academic knowledge and skills within thermal processes to a practical problem and process the problem

Type of instruction
Problem based and project oriented work in project groups.

It is a pre-condition for students who have not studied the Aalborg PBL model at Aalborg University that they have passed the course in Problem Based Learning and Project Management prior to the project examination, see section 3.5.a.

Teaching is in English and/or Danish depending on the participation of international students, or if the supervisor is of foreign origin.
Examination format
Oral examination with external adjudicator based on a presentation of the project report in accordance with the rules of the Examination Policies and Procedures, Addendum to the Joint Programme Regulations of the Faculty of Engineering and Science, Aalborg University.

Assessment criteria
As stated in the Joint Programme Regulations.


Title
B6-4 Sustainable Energy Systems: Economics, Environment, and Public Regulation/Bæredygtige energisystemer: Økonomi, miljø og offentlig regulering

Objective
Students who complete the module should:

Knowledge
- Understand how different energy systems affect society and environment
- Understand the theoretical ideas and principles applied in economic and environmental assessment
- Understand the primary paths of interaction between energy systems, economics, technology and market developments, and public regulation
- Know how issues of energy, environment, and economics are handled by national and international policy makers, companies, and markets
- Know existing methods and models used for preparing energy, environmental and economic analyses (3E methods and models)

Skills
- Assess environmental consequences from utilizing various energy resources and technologies, focusing on atmospheric emissions and climate impacts
- Apply economic thinking and methods for optimizing solutions to problems in engineering.
- Implement qualified and methodologically appropriate techno-economic assessments of engineering projects, focusing on energy technology projects
- Design and implement advanced techno-economic modelling to address current problems in energy planning

Competences
- Be able to provide sound and sober judgement about selecting and implementing the best methods and models for assessing energy, environmental and economic consequences from engineering activities
- Be able to apply a sound and sober assessment of results and conclusions obtained by different models and methods

Type of instruction
Lectures, exercises and workshops supplemented with interactive seminars on issues of current interest and importance.

Examination format
Portfolio-based oral examination with internal examiner.

Assessment criteria
Are stated in the Joint Programme Regulations.
3.6.e. Course Module on 6th Semester: Design and Control of Hydraulic Systems

Title
B6-5 Design and Control of Hydraulic Systems/Design og regulering af hydrauliske systemer

Prerequisites
The module is based on knowledge achieved in the modules Calculus, Linear algebra, Applied engineering mathematics, Fundamental control theory and Introduction to mechanics and thermodynamics or similar

Objective
Students who complete the module should:

Knowledge
- Have knowledge about and comprehension of various fluid power components and their function
- Have knowledge about fluid power diagrams
- Have knowledge about and comprehension of fluid power system design
- Have knowledge about and comprehension of both steady state and dynamic modelling of fluid power components and systems
- Have knowledge about and comprehension of classic controllers for fluid power systems
- Have knowledge about an industrial servo-system and its structure

Skills
- Be able to model and analyse fluid power systems
- Be able to design fluid power systems
- Be able to design and dimension basic linear controllers for fluid power servo-systems

Competences
- Be able to solve development-oriented situations with relation to fluid power systems
- Independently be able to participate in disciplinary and interdisciplinary collaboration with a professional approach with relation to fluid power system

Type of instruction
The teaching is organised according to the general teaching methods of the study programme, see chapter 3. Teaching is in English and/or Danish depending on the participation of international students, or if the supervisor is of foreign origin.

Examination format
Individual, written examination based on theoretical theory combined with a mini project applying dynamic analysis and controller design in accordance with the rules in the Examination Policies and Procedures.

Assessment criteria
As stated in the Joint Programme Regulations.

3.6.f. Course Module on 6th Semester: Electrical Power Systems

Title
B6-6 Electrical Power Systems/Elektriske anlæg

Prerequisites
The module is based on knowledge achieved in the modules AC circuit theory and Electrical machines or similar
Objective
Students who complete the module should:

Knowledge
- Have knowledge about calculation and measurement of the characteristic quantities of electrical power systems
- Have knowledge about calculation of voltages, currents, active and reactive power transfer in simple and composite transmissions and distribution networks
- Have knowledge about power flow and the belonging most applied analytical and numerical calculation methods
- Have knowledge about symmetrical components, their calculation and usage
- Have knowledge about calculation of currents and voltages for single phase and multiphase faults in the electricity grid for varying types of grounding circuits in simple and composite transmission and distribution networks
- Have knowledge about Fourier series and harmonic functions and their relevance in relation to power systems

Skills
- Be able to analyse various electrical power system components in such a way that their characteristic electrical quantities may be determined
- Be able to apply the electric power system characteristic quantities to calculate the power flow in transmission and distribution networks, including low voltage networks
- Be able to develop numerical methods to calculate the power flow in transmission and distribution networks, including low voltage networks
- Be able to calculate the distribution of short circuit currents for symmetrical and unsymmetrical faults in transmission and distributions networks, including low voltage networks
- Be able to apply Fourier analysis on relevant scenarios in power systems

Competences
- Be able to handle simple development oriented situations in relation to power systems under normal conditions or during faults
- Independently be able to participate in disciplinary and interdisciplinary collaboration with a professional approach in the field of power system fundamentals
- Be able to identify one’s own learning needs and to structure one’s own learning in electrical power systems

Type of instruction
Lectures, laboratory work and practical exercises. Teaching is in English and/or Danish depending on the participation of international students, or if the supervisor is of foreign origin.

Examination format
Individual, 4-hour written examination in accordance with the rules in the Examination Policies and Procedures.

Assessment criteria
As stated in the Joint Programme Regulations.

3.6.g. Course Module on 6th Semester: Chemical Thermodynamics and Process Optimisation

Title
B6-7 Chemical Thermodynamics and Process Optimisation/Kemisk termodynamik og procesoptimering
Prerequisites
The module is based on knowledge achieved in the modules Fundamental energy system physics and topology, Thermodynamics, heat transfer and fluid dynamics and Modelling of thermal systems or similar

Objective
Students who complete the module should:

Knowledge
- Have knowledge about methods for determining thermal and calorimetric properties for pure fluids and mixtures as well as the calculation of chemical equilibrium
- Have knowledge about the interaction between chemical thermodynamics and combustion processes
- Have knowledge about fundamental methods for optimization of thermal and chemical energy systems using process integration

Skills
- Be able to understand and use the thermal property relations for pure fluids, multiphase systems and general mixtures
- Be able to determine chemical equilibrium
- Be able to conduct multiphase calculations for pure fluids on one or multiple phases and gas-/liquid mixtures
- Be able to conduct general psychrometric calculations; such as processes with humid air
- Be able to use the fundamental chemical thermodynamics in the calculation of chemical reactions related to stoichiometric and non-stoichiometric combustion
- Be able to understand the synthesis within thermal/chemical core processes, separation and recirculation systems and heat exchanger networks
- Be able to design optimum supply systems for the operation of thermal- and chemical processes
- Be able to use fundamental process integration methods on thermal and chemical systems

Competences
- Have the ability to use the topic interdisciplinary with other topics
- Be able to evaluate the best method of analysis related to the determination of thermal and calorimetric properties for a given process
- Be able to determine calorimetric conditions during combustion such as heating value and adiabatic flame temperature
- Be able to interpret the result of process integration calculations on thermal energy systems

Type of instruction
Lectures supplemented with self-study and/or study circles. Teaching is in English and/or Danish depending on the participation of international students, or if the supervisor is of foreign origin.

Examination format
Individual, oral exam based on the syllabus in accordance with the rules in the Examination Policies and Procedures.

Assessment criteria
As stated in the Joint Programme Regulations.

3.6.h. Course Module on 6th Semester: Flow Machines

Title
B6-8 Flow Machines/Strømningsmaskiner
Prerequisites
The module is based on knowledge achieved in the modules Introduction to mechanics and ther-
modynamics, Applied engineering mathematics, Thermodynamics, heat transfer and fluid dynam-
ics and Modelling of thermal systems or similar

Objective
Students who complete the module should:

Knowledge
- Have knowledge about single and multi-stage flow machinery
- Have knowledge about fundamental fluid mechanical analysis methods
- Be able to understand the governing mechanisms related to the abovementioned pro-
cesses

Skills
- Be able to use control volume analysis on fundamental fluid mechanical problems
- Be able to dimension components for flow machinery

Competences
- Have the ability to use the topic in an interdisciplinary way with other topics
- Be able to explain the problem and the used method of solution for persons not knowl-
edgeable in this
- Be able to interpret the result and present the overall conclusions

Type of instruction
Lectures supplemented with self-study and/or study circles. Teaching is in English and/or Danish
depending on the participation of international students, or if the supervisor is of foreign origin.

Examination format
Individual, oral examination based on a mini project in accordance with the rules in the Examina-
tion Policies and Procedures.

Assessment criteria
As stated in the Joint Programme Regulations.

3.6.i. Course Module on 6th Semester: State Space and Digital Control

Title
B6-9 State Space and Digital Control/Tilstandsregulering og diskret regulering

Prerequisites
The module is based on knowledge achieved in the module Fundamental control theory or similar

Objective
Students who complete the module should:

Knowledge
- Have knowledge about state space models and representation of systems on state space
  format
- Have knowledge about canonical forms and their connection with transfer functions
- Have knowledge about the systems behaviour and stability properties seen in relation to
  the eigenvalues of the system
- Have knowledge about controllability and observability
- Have knowledge about pole placement and state observer design
- Have knowledge about sampling and reconstruction of time continuous signals
- Have knowledge about methods for analysis of discrete-time signals and systems using
  the Z-transform
Have knowledge about methods for design of discrete-time controllers
Have knowledge about methods for discretization of continuous time controllers

**Skills**
- Be able to model linear time invariant continuous systems using state space representation
- Be able to solve state space equations and be able to analyse responses and stability properties using state space models
- Be able to design state space controllers and observers for a time continuous system
- Be able to model and analyse both open loop and closed loop discrete time systems
- Be able to select a sampling time
- Be able to formulate specifications for a closed loop system and be able to select a suitable discrete time controller
- Be able to design a discrete time controller in the $Z$-domain
- Be able to use methods for discretization of a continuous time controllers and be able to evaluate the usefulness of the obtained discrete controller
- Have understanding of the practical implementation of discrete time controllers

**Competences**
- Be able to handle development oriented situations related to state space control and discrete time control
- Be able to enter into an academic and interdisciplinary cooperation in state space control and discrete time control
- Be able to identify own learning needs and structure own learning related to state space control and discrete time control

**Type of instruction**
The teaching is organised according to the general teaching methods of the study programme, see chapter 3. Teaching is in English and/or Danish depending on the participation of international students, or if the supervisor is of foreign origin.

**Examination format**
Individual, written examination in accordance with the rules in the Examination Policies and Procedures.

**Assessment criteria**
As stated in the Joint Programme Regulations.

**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 1 September 2015.

Students who wish to complete their studies under the previous curriculum from 2010 must conclude their education by the summer examination period 2017 at the latest, since examinations under the previous curriculum will not be offered after that date.

According to the Joint Programme Regulations of the Faculty of Engineering and Science and the Faculty of Medicine at Aalborg University, the curriculum must be reviewed no later than 5 years after its entry into force.

**5. Other Provisions**
**5.1 Rules concerning Written Work, including the Bachelor's Thesis**
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 formulation 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 language performance alone; similarly, an examination 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 thesis must include a summary in English\(^1\). If the thesis is written in English, the summary must be written in Danish\(^2\). The summary must be at least 1 page and not more than 2 pages (not included in any minimum or 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 of Choice of Modules that are part of Another Programme at a University in Denmark or Abroad.**

In the individual case, the Study Board can approve successfully completed (passed) programme elements from other Bachelor’s programmes in lieu of programme elements in this programme (credit transfer). The Study Board can also approve successfully completed (passed) programme elements from another Danish programme or a programme outside of Denmark at the same level in lieu of programme elements within this curriculum. Decisions on credit transfer are made by the Study Board based on an academic assessment. See the Joint Programme Regulations for the rules on credit transfer.

**5.3 Rules concerning the Progress of the Bachelor’s Programme**

The student must participate in all first year examinations by the end of the first year of study in the Bachelor's programme, in order to be able to continue the programme. 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 programme.

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 Programme**

Bachelor's degree must be completed within six years after its commencement.

**5.5 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.

**5.6 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.

**5.7 Rules and Requirements for the Reading of Texts**

At programmes taught in Danish, it is assumed that the student can read academic texts in modern Danish, Norwegian, Swedish and English and use reference works, etc., in other European. At programmes taught in English, it is assumed that the student can read academic text and use reference works, etc., in English.

**5.8 Additional Information**

The current version of the curriculum is published on the Study Board of Energy’s website, including more detailed information about the programme, including exams.

\(^1\) Or another foreign language (French, Spanish or German) upon approval by the Study Board

\(^2\) The Study Board can grant exemption from this