The Faculty of Engineering and Science
Board of Studies for Industry and
Global Business Development

AALBORG UNIVERSITY
DENMARK

Curriculum for Master's Programme in Electro-Mechanical System Design

Aalborg University
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Preface:
Pursuant to Act 261 of March 18, 2015 on Universities (the University Act) with subsequent changes, the following curriculum for the Master programme in Electro-Mechanical System Design is stipulated. The programme also follows the Joint programme regulations and the Examination Policies and Procedures for the Faculties of Engineering and Science.

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Chapter 1: Legal Basis of the Curriculum, etc.

1.1 Basis in Ministerial Orders

The Master programme in Electro-Mechanical System Design is organised in accordance with the Ministry of Science, Innovation and Higher Education's Order no. 1328 of November 15, 2016 on Bachelor's and Master's Programs at Universities (the Ministerial Order of the Study Programs) and Ministerial Order no. 1062 of June 30, 2016 on University Examinations (the Examination Order). Further reference is made to Ministerial Order no. 111 of January 30, 2017 (the Admission Order) and Ministerial Order no. 114 of February 3, 2015 (the Grading Scale Order) with subsequent changes.

1.2 Faculty Affiliation

The Master programme falls under the Faculty of Engineering and Science, Aalborg University.

1.3 Board of Studies Affiliation

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

1,4 Body of External Examiners
The Master's programme falls under the Body of External Examiner Corps for Engineers (Ingeniørernes landsdækkende censorkorps (maskin)).

Chapter 2: Admission, Degree Designation, Programme Duration and Competence Profile

2.1 Admission
Applicants with a legal right of admission (retskrav):

- Aalborg University offers no bachelor's programmes with a legal right of admission to this Master's programme

Applicants without legal right of admission:
Bachelor's programmes qualifying students for admission:

- Bachelor of Science in Mechanical Engineering and Manufacturing, Aalborg University

Students with another Bachelor degree may, upon application to the Board of Studies, be admitted following a specific academic assessment if the applicant is considered as having comparable educational prerequisites. The University can stipulate requirements concerning conducting additional exams prior to the start of study.

2.2 Degree Designation in Danish and English
The Master programme entitles the graduate to the Danish designation civilingeniør, cand.polyt. (candidatus/candidata polytechnices) i elektro-mekanisk systemdesign. The English designation is: Master of Science (MSc) in Engineering (Electro-Mechanical System Design).

2.3 The Programme's Specification in ECTS Credits
The Master programme is a 2-year, research-based, full-time study programme. The programme is set to 120 ECTS credits.

2.4 Competence profile on the diploma

The following competence profile will appear on the diploma:

> **A Candidatus graduate has the following competency profile:**
> A Candidatus graduate has competencies that have been acquired via a course of study that has taken place in a research environment.
> A Candidatus graduate is qualified for employment on the labour market on the basis of his or her academic discipline as well as for further research (PhD programmes). A Candidatus graduate has, compared to a Bachelor, developed his or her academic knowledge and independence so as to be able to apply scientific theory and method on an independent basis within both an academic and a professional context.

2.5 Competence Profile of the Programme

The graduate of the Master programme:

Knowledge	• Has gained an extensive knowledge within the areas related to analysis and design of electro mechanical systems. • Has knowledge in one or more subject areas that, in selected areas within electronic, mechanical or control engineering, are based on the highest international research in the subject areas. • Can understand and, on a scientific basis, reflect over the subject areas within electro mechanical system design and identify scientific problems.
Skills	• Excels in the subject areas, scientific methods and tools and general skills related to employment within the subject area. • Can evaluate and select among the subject area's(s') scientific theories, methods, tools and general skills and, on a scientific basis, advance new analyses and solutions. • Can communicate research-based knowledge and discuss professional and scientific problems with both peers and non-specialists.
Competences	• Can, on a highly qualified manner, take part in technical development and research. • Can manage work and development situations that are complex, unpredictable and require new solutions. • Can independently initiate and implement discipline-specific and interdisciplinary cooperation and assume professional responsibility. • Can independently take responsibility for own professional development and specialization.

Chapter 3: Content and Organisation of the Programme

The MSc programme in Electro-Mechanical System Design aims at educating graduates who are qualified to take part in technical development and research and who are able to direct the technical management of development projects within the industry.

The graduates are expected to have gained a broad knowledge within the areas of mechatronic system design, modelling and analysis of electro mechanical systems, information technology and control theory. Emphasis will be put on disciplines such as modelling of multi domain systems, simulation, system optimisation, and control engineering.

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 defined in the curriculum.

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

- Lectures
- Classroom instruction
- Project work
- Workshops
- Exercises (individually and in groups)
- Teacher feedback
- Reflection
- Portfolio work.

The 3rd semester offers different ways of organisation – depending on the student's choice of content; project work at Aalborg University, study visit at an educational institution in Denmark or abroad, voluntary traineeship with project work at a company in Denmark or abroad, or a semester programme that comprises cross-disciplinary programme elements composed by the student. The total work load of the semester must be equivalent to 30 ECTS of which up to 15 ECTS can be elective courses. The project may be finalised with a project report or in the form of a scientific paper, or, if the project is continued on the 4th semester, with a midterm evaluation. For further information about the organisation of the module, please see the Joint programme regulations, chapter 2.3, and the study guide for the MSc programme in Electro-Mechanical System Design.

On the 4th semester, the Master's Thesis is completed. The Master's Thesis may be combined with the 3rd semester in an extended Master's Thesis.

Overview of the Programme

All modules are assessed through individual grading according to the 7-point scale *or* Pass/Fail. All modules are assessed by external examination (external grading) or internal examination (internal grading or by assessment by the supervisor only).

Semester	Module	ECTS	Grading	Exam
1.	Electrical and Fluid Power Servomechanisms	15	7-point scale	External
	Control of Fluid Power and Electrical Servomechanisms	5	7-point scale	Internal
	Embedded Micro Processors: Applications and C Programming	5	7-point scale	Internal
	Finite Element Methods	5	7-point scale	Internal
2.	Design and Control of Power Transmission Systems	15	7-point scale	Internal
	Engineering Optimisation – Concepts, Methods and Applications	5	7-point scale	Internal
	Multi Variable Control	5	7-point grading scale	Internal
	AC Motor Drives: Converters and Control	5	7-point scale	Internal
3.	Industrial Development	15, 20, 25, 30	7-point scale	Internal
	Academic Internship[1]	15, 20, 25, 30		
	Elective courses*			
	System Identification and Diagnosis	5	7-point scale	Internal
	Non-linear Control and Multi-body Systems	5	7-point scale	Internal
	Test and Validation	5	Pass/Fail	Internal
4[2].	Master's Thesis	30, 45, 50, 60	7-point scale	External

*Courses on the 3rd semester are elective and the student can choose up to 15 ECTS course credits.

[1] The academic traineeship has to be approved by the study board before the beginning of the semester.
[2] The master thesis can be conducted as a long master thesis using both the 3rd and 4th semester. If choosing to do a long master thesis, it has to include experimental work and has to be approved by the study board.

3.2 Electro-Mechanical System Design, 1st Semester

3.2.0 Problem Based Learning and Project Management

Title:
Problem Based Learning and Project Management
(Problembaseret læring og projektledelse)

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

Objective:
The objective is to make newly started Master students coming from institutions other than AAU prepared to enter the problem based learning environment at AAU and manage study projects in close collaboration with peers.

Type of instruction:
Three half day workshops centered around 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 their individual challenges/curiosities in a peer learning group.

Learning outcomes: After completion of the course the student should be able to

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

Day2:
- 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

Form of examination:
Internal assessment during the course/class participation according to the rules in the Examination Policies and Procedures of Faculty of Engineering and Science, Aalborg University. In this case the assessment is primarily based on the oral performance during the course, which 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 precondition 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:
As stated in the Joint programme regulations

3.2.1 Electrical and Fluid Power Servomechanisms

Title: **Electrical and Fluid Power Servomechanisms (15 ECTS)**
(Elektriske og hydrauliske servomekanismer)

Goal: Students who complete the module are expected to:

Knowledge

- Have gained in-depth understanding of theoretical and experimental mode of operation of electrical and hydraulic servomechanisms.
- Have attained an understanding for methods of analysis and experimental methods and the characteristics of their applications and limitations.

Skills

- Be able to set up the governing equations a servomechanism
- Be able to specify performance criteria for a given application
- Be able to design linear controllers for a servomechanism
- Be able to implement a controller digitally
- Be able to analyse a computer controlled system
- Be able to use information technology tools to analyse and design of computer-controlled systems
- Be able to use correct terminology
- Be able to compare theoretical and experimental results
- Be able to critically evaluate applied methods and their results

Competences

- Be able to analyse and design a hydraulic or electrical servomechanism on a model based approach. The system being a complex mechatronic system encompassing mechanical, electrical and control engineering elements requiring a creative design method
- Be able to implement a computer-controlled system addressing areas important for development in the field such as process knowledge, measurement technology, computer technology and control theory
- Be able to compare, evaluate and validate theoretical and experimental results carefully, and critically evaluate the methods applied and the results obtained.

Teaching Method: Project work.

Form of examination: External, oral examination.

Evaluation criteria: As stated in the Joint programme regulations.

3.2.2 Control of Fluid Power and Electrical Servomechanisms

Title: **Control of Fluid Power and Electrical Servomechanisms (5 ECTS)**
(Regulering af hydrauliske og elektriske servomekanismer)

Goal: Students who complete the module are expected to:

Knowledge

- Have gained an understanding of analysis, design and control of hydraulic servo mechanisms
- Have gained knowledge about methods for electro-mechanical energy conversion by means DC and square-wave brushless machines
- Have gained knowledge about the construction, the operating principles, the modelling and the performance characteristics for DC and brushless machines
- Have a basic understanding about closed-loop control principles for DC and brushless machines for servo applications
- Have a fundamental understanding of permanent magnet materials and their applications in electric actuators
- Have gained knowledge about methods for electric energy conversion by power electronic converters
- Have gained knowledge about active and passive power electronic components and their use in power converters.
- Have gained an understanding of Lagrange equation and how it is used for modelling of a mechanical system.
- Have a basic understanding of non-linarites in mechanical system including modal interaction.

Skills

- Be able to set up the governing equations (physically based) for a hydraulic servo system
- Be able to apply linear control strategies to a hydraulic servo system
- Be able to analyse different kinds of DC machines and to formulate dynamic models hereof
- Be able to calculate performance characteristics for the DC machine and to select a DC motor for a given application
- Be able to analyse and to design servo systems using DC machines with speed, position and current feedback
- Understand the basics of square-wave permanent magnet brushless machines and their applications for servo mechanisms
- Be able to understand the operating principles for basic electric converters, including pulse-width modulated buck, boost, half- and full-bridge converters
- Understand the fundamentals of semiconductor physics and the basic operating principles for power semiconductor devices such as power diodes and MOSFET’s
- Be able to read power semiconductors datasheets, including understanding of switching characteristics and safe operating areas
- Be able to design simple power electronic converters, including gate drivers and thermal aspects such as switching and conduction losses
- Have a basic understanding of good circuit layout techniques for switching converters.
- Be able to set up a dynamic model for mechanical system using Lagrange equation.

Competences

- Have the ability to model and analyse a hydraulic servo system, thereby being able to set up performance criteria and identify performance limitations
- Be able to design and implement linear controllers for hydraulic servo mechanisms and evaluate and validate the performance obtained
- Have the ability to design, model and simulate a servo system based on either a DC machine or a square-wave brushless machine
- Be able to design a closed-loop servo control system taking component limitations into account and to use a power electronic converter as part of the actuator system
- Be able to design simple power electronic converters, including component selection and proper thermal management.

Teaching Method: cf. section 3.

Form of examination: Internal, oral/written examination

Evaluation criteria: As stated in the Joint programme regulations.

3.2.3 Embedded Micro Processors: Applications and C Programming

Title: **Embedded Micro Processors: Applications and *C* Programming (5 ECTS)**
(Indlejrede mikroprocessorer: anvendelse og C programmering)

Goal: Students who complete the module are expected to:

Knowledge

- Have gained a fundamental knowledge about *C*/*C*++ programming and have a basic understanding of structured object-oriented programming
- Have attained a basic understanding of the architecture and the applications of micro processors, including digital signal processors (DSP) and micro controller units (MCU)
- Have gained experience with programming of DSP's and MCU's for real-time applications, including interfacing to peripheral units

Skills

- Be able to understand basic *C* syntax, including *C* data types, statements, loop constructs and functions
- Be able to understand basic object-oriented programming concepts, including classes, objects, scope, constructors, destructors and inheritance
- Be able to use pointers, arrays and function pointers in C
- Be able to use static and dynamic memory allocation
- Be able to understand the interrupt concept and its use for real-time task scheduling and prioritisation
- Be able to understand basic architectures used in micro processor systems
- Be able to understand and to configure a micro processor's built-in peripheral units
- Be able to understand the role and application of peripheral serial interfaces such as e.g. SPI and I2C
- Be familiar with *C*/*C*++ development tool chains and the use of integrated development environments

Competences

- Have the ability to develop and to test algorithms in *C* and *C*++ for real-time micro processor applications
- Be able to use peripheral units such as e.g. A/D converters, timers, pulse-width modulator units, encoder interface for interfacing an DSP/MCU to external devices such as sensors and actuators
- Be able to implement control and monitoring algorithms taking timing and prioritisation aspects into account
- Be able to apply serial interfaces for communication with external devices such as e.g. D/A converters and intelligent sensors

Teaching Method: cf. section 3.

Form of examination: Internal, oral/written examination

Evaluation criteria: As stated in the Joint programme regulations.

3.2.4 Finite Elements Methods

Title: **Finite Element Methods (5 ECTS)**
(Elementmetoder)

Goal: Students who complete the module are expected to:

Knowledge

- Be able to use the finite element method in static stress analysis
- Have knowledge of element technology, such as bar, beam, solid and shell elements
- Be able to apply methods for error estimation and adaptive mesh generation.
- Be able to solve structural dynamics and vibrations problems using methods such as free vibrations, modal methods and direct time integration methods
- Be able to apply nonlinear finite element methods including solution of systems of nonlinear equations, geometrically nonlinear problems, contact problems and nonlinear material models
- Be able to perform linearised buckling analysis
- Be able to solve exercises using a commercial finite element programme (e.g., ANSYS).

Skills

- Demonstrate a basic understanding of concepts, theory and applications of finite element analysis from a mechanical engineering viewpoint
- Be able to perform linear and nonlinear static and dynamic stress analysis including the use of commercial finite element software.

Competences

- Be able to apply the concepts, theories and techniques covered in the area of linear and nonlinear finite element analysis on practical problems
- Be able to apply the concepts and theories to the solution of relevant problems using commercial software programmes.

Teaching Method: cf. section 3.

Form of examination: Internal, oral/written examination

Evaluation criteria: As stated in the Joint programme regulations.

3.3 Electro-Mechanical System Design, 2nd Semester

3.3.1 Design and Control of Power Transmission Systems

Title: **Design and Control of Power Transmission Systems (15 ECTS)**
(Design og regulering af effektoverførende systemer)

Recommended academic prerequisites:
This module is based on knowledge gained on 1st Semester of the MSc programme in Electro-Mechanical System Design.

Goal: Students who complete the module are expected to:

Knowledge

- Have gained knowledge and understanding of design of a power transmission system featuring a poly phase AC motor
- Be able to, on a scientific basis, to understand and apply advanced model based analysis tools for evaluating the performance of a power transmission system

Skills

- Be able to set up the governing equations for a poly phase AC machine.
- Be able to understand the function of a frequency converter
- Be able to master the conventional control strategies for control of a poly phase AC machine
- Be able to understand the interaction between motor, frequency converter and the actuated plant
- Be able to apply advanced analysis theory and tools for optimising the performance of a power transmission system
- Be able to implement control strategies digitally

Competences

- Be able to design a power transmission system involving control of a poly phase AC machine taking into account the dynamic properties of the actuated system
- Be able to handle a multidisciplinary problem of high complexity that requires use of both the understanding of the innovative process of mechatronic design methodology and new design methods

Teaching Method: Project work

Form of examination: Oral examination with participation of an internal examiner.

Evaluation criteria: As stated in the Joint programme regulations.

3.3.2 Engineering Optimisation – Concepts, Methods and Applications

Title: **Engineering Optimisation – Concepts, Methods and Applications (5 ECTS)**
(Ingeniørmæssig optimering – begreber, metoder og anvendelser)

Recommended academic prerequisites:
This module is based on knowledge gained on 1st Semester of the MSc programme in Electro-Mechanical System Design.

Goal: Students who complete the module are expected to:

Knowledge

- Have gained in-depth understanding of important concepts and methods of optimisation for efficient solution of optimisation problems within different areas of engineering, including design optimisation of mechanical systems

Skills

- Be able to use optimisation concepts and topics
- Be able to use numerical methods of unconstrained optimisation.
- Be able to use numerical (mathematical programming) methods for optimisation of multi-dimensional functions with constraints
- Be able to solve multi-criterion optimisation problems
- Be able to apply other methods of optimisation, such as integer problems, response surface methods, genetic algorithms, etc.
- Be able to perform general applications of optimisation methods: parameter identification, optimisation as an analysis tool for problems governed by an extremum principle, surrogate and meta modelling problems

Competences

- Be able to apply the concepts, theories and methods for solution of engineering optimisation problems
- Be able to account for the considerations involved in the process of formulating and modelling an engineering optimisation problem, choosing an advantageous method of solution and implementing it in practice

Teaching Method: cf. section 3.

Form of examination: Internal, written/oral examination

Evaluation criteria: As stated in the Joint programme regulations.

3.3.3 Multi Variable Control

Title:
Multi Variable Control (5 ECTS)
(Multivariabel regulering)

Recommended academic prerequisites:

The module is based on knowledge achieved in classical control theory and state space control.

Objective
Students who complete the module should:

Knowledge

- Have gained an in-depth understanding of basic aspects of multivariable control design, the approaches, the key quantities to consider and the fundamental limitations inherent in the design
- Be able to, on a scientific basis, to understand and apply advanced model based control design tools
- Be able to document understanding of multivariable systems (multiple inputs and multiple outputs MIMO)

Skills

- Be able to understand the fundamental performance limitations of single input and single output (SISO) systems
- Be able to represent linear systems in different ways: Transfer functions matrices, input-output equations, state space form, etc.
- Be able to understand what disturbances are, and to describe their character in a suitable way
- Be able to set up design specifications for MIMO systems
- Be able to understand basic limitations in control design
- Be able to set up the configuration of multivariable controllers
- Be able to design linear multivariable controllers

Competences

- Be able to undertake analysis, design and implementation of advanced multivariable control systems where experience and intuition play a very important role

Type of instruction
The form(s) of teaching will be determined and described in connection with the planning of the semester. The description will account for the form(s) of teaching and may be accompanied by an elaboration of the roles of the participants (see chapter 3).

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

Assessment criteria
As stated in the Joint Programme Regulations.

3.3.4 AC Motor Drives: Converters and Control

Title: **AC Motor Drives: Converters and Control (5 ECTS)**
(AC motor drev: konvertere og regulering)

Recommended academic prerequisites:
This module is based on knowledge gained on 1st Semester of the MSc programme in Electro-Mechanical System Design.

Goal: Students who complete the module are expected to:

Knowledge

- Have gained knowledge of methods for electro-mechanical energy conversion by means of three-phase AC machines
- Have gained knowledge of the construction and the operating principles for induction machines and for three-phase sine-wave brushless machines
- Understand the stationary performance characteristics for such machines
- Have a solid understanding of stationary and dynamic models of AC machines
- Have gained a solid understanding of basic methods for speed control of AC machines using power electronic converters
- Have gained a basic understanding of high-performance torque control methods based on vector-control principles
- Have gained knowledge of power electronic converters for AC drives
- Have knowledge of dynamic models of power converters
- Understand the principle of three-phase pulse-width modulation (PWM) for three-phase systems and being able to apply PWM as part of an AC motor control loop

Skills

- Be able to explain the operating principles for induction and brushless machines
- Be able to apply equivalent circuit diagrams for stationary performance analysis
- Be able to measure motor parameters using standard tests
- Be able to make dynamic models of AC machines using space-vector models in stationary and rotating coordinates
- Be able to design and to simulate simple scalar control techniques for AC machines based on stationary performance characteristics
- Be able to understand field-oriented control techniques and to apply these for high-performance AC drives
- Be able to design a pulse-width modulator using both carrier-based and space-vector based approaches
- Being able to analyse and to model single- and three-phase power converters taking component voltage drops and blanking effects into account

Competences

- Have the ability to analyse, model and simulate the stationary and dynamic characteristics for an AC motor drive based on both induction and permanent-magnet machines
- Be able to design a complete AC motor control system using either classical V/Hz techniques or high-performance vector-control techniques based on field-orientation and instantaneous current control

Teaching Method:cf. section 3.

Form of examination: Internal, written/oral examination

Evaluation criteria: As stated in the Joint programme regulations.

3.4 Electro-Mechanical System Design, 3rd Semester

3.4.1 Industrial Development

Title: **Industrial Development (15, 20, 25, 30 ECTS)**
(Industrielt udviklingsarbejde)
The extent of the project must reflect the allotted time in ECTS

Recommended academic prerequisites:
This module is based on knowledge gained on 2nd Semester of the MSc programme in Electro-Mechanical System Design.

Goal: Students who complete the module are expected to:

Knowledge

- Have gained knowledge and understanding of advanced engineering design of electro-mechanical systems (Mechatronic systems)
- Be able to understand and apply advanced analysis and design tools for evaluating the performance of advanced electro-mechanical systems
- Have knowledge and comprehension of design methodology for mechatronic systems

Skills

- Be able to describe the problem solved and the criteria applied for its solution
- Be able to evaluate the concepts, theories and methodologies applied in the solution of the problem
- Be able to account for the choices made during the solution of the problem, and substantiate that these are made on a high professional level
- Be able to assess the limitations of the concepts, theories and methodologies applied in the solution of the problem

Competences

- Be able to analyse and solve an actual problem of industrial relevance through application of systematic research and development processes, including advanced analytical, experimental and/or numerical methods and models

Organisation: The project can be combined with up to 15 ECTS of courses, which reduces the ECTS of the project accordingly (e.g., a 20 ECTS project combined with 10 ECTS of course-work). The semester must add up to a total workload of 30 ECTS. The project may be finalized with a project report or in the form of a scientific paper with supporting appendices.

Teaching Method: Project work

Form of examination: Oral examination

Evaluation criteria: As stated in the Joint programme regulations.

3.4.2 Academic Internship

Title: **Academic Internship (15, 20, 25, 30 ECTS)**
(Projektorienteret forløb i en virksomhed)
The extent of the project must reflect the allotted time in ECTS

Recommended academic prerequisites:
This module is based on knowledge gained on 2nd Semester of the MSc programme in Electro-Mechanical System Design.

Goal: Students who complete the module are expected to:

Knowledge

- Have gained knowledge and understanding of advanced engineering design of electro-mechanical systems (Mechatronic systems)
- Be able to understand and apply advanced analysis and design tools for evaluating the performance of advanced electro-mechanical systems
- Have knowledge and comprehension of design methodology for mechatronic systems

Skills

- Be able to describe the problem solved and the criteria applied for its solution
- Be able to evaluate the concepts, theories and methodologies applied in the solution of the problem
- Be able to account for the choices made during the solution of the problem, and substantiate that these are made on a high professional level
- Be able to assess the limitations of the concepts, theories and methodologies applied in the solution of the problem

Competences

- Be able to analyse and solve an actual problem of industrial relevance through application of systematic research and development processes, including advanced analytical, experimental and/or numerical methods and models

Organisation: This type of project can be combined with up to 15 ECTS of courses, which reduces the ECTS of the project accordingly (e.g., a 20 ECTS project combined with 10 ECTS of course-work). The semester must add up to a total workload of 30 ECTS.

Teaching Method: Project work

Form of examination: Oral examination

Evaluation criteria: As stated in the Joint programme regulations.

3.5 Elective courses, 3rd semester

3.5.1 Non-linear Control and Multi-body Systems (5 ECTS)

Title:
Non-linear Control and Multi-body Systems
(Ikke-lineær regulering og flerlegeme systemer)

Objective
Students who complete the module should:

Knowledge

- Be able to carry out kinematic analysis of multi-body systems
- Be able to model multi-body dynamical systems using selected methods
- Be able to develop complete system models that include actuators and possible hard non-linearities
- Be able to analyse systems using linearization-, Lyapunov- and phase plane methods
- Be able to design non-linear controllers for considered systems in the presence on uncertain and possibly varying system parameters

Skills

- Be able to establish various types models for non-linear system, including multi-body and actuator models
- Be able to judge the usefulness of the different analyses and design methods
- Be able to apply the learned knowledge to analyse and study non-linear dynamical systems
- Be able to design selected types of non-linear controllers
- Be able to implement selected types of non-linear controllers

*Competence*s

- Independently be able to describe and analyse non-linear systems
- Independently be able to design considered non-linear controllers
- Independently be able to continue own development within the field of non-linear systems analysis and control

Type of instruction
The form(s) of teaching will be determined and described in connection with the planning of the semester. The description will account for the form(s) of teaching and may be accompanied by an elaboration of the roles of the participants (see chapter 3).

Examination format
Internal, written/oral examination

Evaluation criteria
As stated in the Joint Programme Regulations.

3.5.1 System Identification and Diagnosis (5 ECTS)

Title:
System Identification and Diagnosis
(Systemidentifikation og diagnosticering)

Objective
Students who complete the module should:

Knowledge
- Have comprehension of the fundamental principles of typical methods of system identification
- Have comprehension of the fundamental concepts, terms and methodologies of abnormal diagnosis
- Have comprehension of some typical model-based and signal-based diagnosis

Skills
- Be able to apply the learned knowledge to handle some simple system identification problems under assistance of a commercial software
- Be able to apply and analyse different diagnosis methods

Competences
- Independently be able to define and analyse scientific problems within the area of system identification and diagnosis
- Independently be able to be a part of professional and interdisciplinary development work within the area of system identification and diagnosis

Type of instruction
The course is taught by a mixture of lectures, workshops, exercises, mini-projects and self-studies.

Examination format
Oral examination

Evaluation criteria
As stated in the Joint Programme Regulations.

3.5.2 Test and Validation (5 ECTS)

Title: **Test and Validation**
(Test og validering)

Recommended academic prerequisites:
The module builds upon knowledge obtained in the modules Applied Statistics and Probability Theory.

Goal: Students who complete the module are expected to:

Knowledge

- Understand methodology for design of experiments and test series and for reduction of ambiguity of experimental results, and for comparability with model predictions
- Explain elementary and advanced quantification tools, and their application to validation between model and experiment data
- Account for common contemporary methods and relevant specific industry standards
- Understand processing methods for analog and digital data (continuous vs. discrete)

Skills

- scrutinize a non-trivial physical systems for appropriate experimental study
- isolate principal measurable parameters
- design an experiment matrix for systematic variation of parameters
- perform a probabilistic study of the experimental data in order to quantify the influence of individual parameters
- scrutinize a model (analytical or numerical) for comparison with an appropriate experimental study
- isolate principal input parameters and their known or assumed statistical variations
- perform a probabilistic study of the model in order to quantify the level of confidence
- account for the level of coherence between test results and model predictions
- Identify invalid data (outliers)
- account for common errors and limitations in the processing of model data or experimentally obtained data

Competences

- undertake experiment planning and execution for refinement and validation (or rejection) of model-based predictions of phenomena within their principal line of study.

Organization: Dependent on student's choice of content and organization of the semester; the student may choose between project work at Aalborg University or a voluntary traineeship at a company in Denmark or abroad. The total work load of the semester has to be equivalent to 30 ECTS. If carried out at Aalborg University, the project may be finalized with a project report or in the form of a scientific paper. If continued at the 4th semester, the project is evaluated with

a midterm evaluation. For further information about the organisation of the module please see the Joint Programme Regulations, chapter 9.4.1.

Teaching Method: Dependent on student's choice of content and organization of the semester;

- If the semester is carried out as an internship, the student is included in the company's daily work and carry out independent project work on an industrial problem relevant for the company. Concurrent to the work in the company, the student makes a project report, which is evaluated after the ending of the internship.
- The project work is carried out as an independent work process in which the students themselves organize and coordinate their workload in collaboration with a supervisor. The project may be carried out individually or in groups.

Form of examination: Oral examination based on submitted written assignment

Evaluation criteria: As stated in the Joint programme regulations.

3.6 Electro-Mechanical System Design, 4th semester

3.6.1 Master's Thesis

Title: **Master's Thesis (30, 45, 50, 60 ECTS)**
(Kandidatspeciale)
The master thesis can be conducted as a long master thesis using both the 3rd and 4th semester. If choosing to do a long master thesis, it has to include experimental work and has to be approved by the study board. The amount of experimental work must reflect the allotted ECTS.

Goal: Students who complete the module are expected to:

Knowledge

- Have attained thorough knowledge of a broad range of theoretical, numerical and experimental methods and techniques within the area of Electro Mechanical System Design, i.e. mechanical engineering, electrical engineering, control engineering and information technology

Skills

- Be able to apply scientific methodology to the solving of a wide variety of problems within the field of specialisation
- Be able to perform scientific work in relevant topics of the field of the specialisation
- Be able to apply a wide range of engineering methods in research and development projects in the field of specialisation
- Be able to participate or lead projects in electro-mechanical development and/or research projects

Competences

- Be able to work independently with a project on a specific problem within their field of interest on the highest possible level within their specialisation
- Be able to take part in technical development and research
- Be able to direct the technical management of development projects within the industry
- Be competent to solve new and complicated technical problems by the use of advanced mathematics, scientific and technological knowledge

Teaching Method: Project work

Form of examination: Oral examination with participation of an external examiner.

Evaluation criteria: As stated in the Joint programme regulations.

Chapter 4: Entry into Force, Interim Provisions and Revision

The curriculum is approved by the Dean of the Faculty of Engineering and Science and enters into force as of September 2017.

Students who wish to complete their studies under the previous curriculum from 2016 must conclude their education by the summer examination period 2018 at the latest, since examinations under the previous curriculum are not offered after this time.

Chapter 5: Other Provisions

5.1 Rules concerning Written Work, including the Master's Thesis

In the assessment of all written work, regardless of the language in which it is written, weight is also put on the student's spelling and formulation ability, in addition to the academic content. Orthographic and grammatical correctness as well as stylistic proficiency are considered basis for the evaluation of language performance. Language performance must always be included as an independent dimension of the total evaluation. However, no examination may be assessed as 'Pass' on the basis of language performance alone; similarly, an examination normally cannot be assessed as 'Fail' on the basis of poor language performance alone. The Board of Studies can grant exemption from this in special cases (e.g., dyslexia or a native language other than Danish).

The Master's thesis must include an English summary.[3] If it is written in English, the summary must be in Danish.[4] The summary must be at least one page and maximum two pages. The summary is included in the evaluation of the project as a whole.

5.2 Rules concerning Credit Transfer (*merit*), including the Possibility for Choice of Modules that are Part of Another Programme at a University in Denmark or Abroad

The Board of Studies can approve successfully completed (passed) programme elements from other Master programmes in lieu of programme elements in this programme (credit transfer). The Board of Studies 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 Board of Studies based on an academic assessment. See the Joint programme regulations for the rules on credit transfer.

5.3 Rules for Examinations

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

5.4 Exemption

In exceptional circumstances, the Board of Studies study 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.

5.5 Additional Information

The current version of the curriculum is published on the Board of Studies' website, including more detailed information about the programme and exams.

[3] Or another foreign language (upon approval from the Board of Studies).
[4] The Board of Studies can grant exemption from this.

5.6 Rules and Requirements concerning the Reading of Texts in Foreign Languages and a Statement of the Foreign Language Knowledge this Assumes

It is assumed that the student is able to read academic texts in modern Danish, Norwegian, Swedish and English and use reference works, etc., in other European languages.