



AALBORG UNIVERSITET

CURRICULUM FOR THE MASTER OF SCIENCE (MSC) PROGRAMME IN SUSTAINABLE ENERGY ENGINEERING 2017

MASTER OF SCIENCE (MSC) IN ENGINEERING
ESBJERG

MODULES INCLUDED IN THE CURRICULUM

TABLE OF CONTENTS

Modelling and Identification of Offshore Systems 2018/2019	4
Problem Based Project Organised Learning in Modelling and Identification of Offshore Systems (INTRO) 2018/2019	7
System Identification and Diagnosis 2018/2019	9
Fluid and Water Wave Dynamics 2018/2019	11
Probability Theory, Stochastic Processes and Applied Statistics 2018/2019	13
Control Theory and MATLAB (INTRO) 2018/2019	15
Dynamic Control of Offshore Electrical Systems 2018/2019	17
Offshore Energy System Technology 2018/2019	19
Control and Surveillance of Processes and Systems 2018/2019	21
Dynamic Modelling of Electrical Machines and Control Systems 2018/2019	23
Advanced Control of Offshore Energy Systems 2018/2019	25
Voluntary Traineeship 2018/2019	28
Master's Thesis 2018/2019	30
Master's Thesis 2018/2019	32
Fluid Mechanical Analysis Methods 2018/2019	34
Problem Based Project organised Learning in Combustion Technology (INTRO) 2018/2019	37
Computational Fluid Dynamics (CFD) and Multiphase Flow 2018/2019	39
Fluid Mechanics and Compressible Flow 2018/2019	41
Combustion and/or Process Systems 2018/2019	43
Process Simulation 2018/2019	45
Combustion Technology and Chemical Reactors 2018/2019	47
Optimisation Theory and Reliability 2018/2019	49
Advanced Combustion and Process Systems 2018/2019	51
Master's Thesis 2018/2019	54
Master's Thesis 2018/2019	56
Advanced Analysis of Thermal Machines 2018/2019	58
Advanced Modelling and Control of Voltage Source Converters 2018/2019	60
Analysis of Advanced Thermal Process Systems 2018/2019	62
Battery Energy Storage Systems 2018/2019	64
Biomass Conversion and Biofuels 2018/2019	66
Biomass Gasification, Combustion and their Advanced Modelling 2018/2019	68
Control of Grid Connected Photovoltaic and Wind Turbine Systems 2018/2019	70
Electrochemical Modelling of Fuel Cells, Electrolysers and Batteries 2018/2019	72
Energy Conversion and Storage in Future Energy Systems 2018/2019	74
Fault Tolerant Control 2018/2019	76
Future Power System in Denmark 2018/2019	78

Curriculum for the Master of Science (MSc) Programme in Sustainable Energy Engineering 2017

Modern Electrical Drives 2018/2019	80
Modern Power Electronic Devices and their Models 2018/2019	82
Non-linear Control and Multi-body Systems 2018/2019	84
Test and Validation 2018/2019	86
Wind Power System and Renewable Energy Grid Integration 2018/2019	88

MODELLING AND IDENTIFICATION OF OFFSHORE SYSTEMS

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension within the design, analysis and modelling of offshore energy systems or subsystems with complex dynamics and elements with linear and non-linear behaviour
- Have knowledge and comprehension within test design and iterate the modelling and identification of components used in offshore energy systems
- Have knowledge and comprehension within modelling of offshore energy systems based on physics as well as data in the form of stochastic systems or processes

SKILLS

- Be able to judge the usefulness of the used different scientific methods for the analysis, modelling, and verification of offshore energy systems and/or components
- Be able to verify the analytical and numerical approaches by means of simple laboratory experiments
- Be able to communicate scientific results by means of papers, posters and oral presentations

COMPETENCES

- Be able to control the working and development process within the project theme and be able to develop new solutions within offshore energy systems
- Independently be able to define and analyse scientific problems for offshore energy systems and subsystems, and based on this be able to make and state the reasons for decisions made, for instance with respect to their influences on the environment
- Independently be able to continue own development in competence and specialisation

TYPE OF INSTRUCTION

Problem based project oriented project work in groups. The project should be based on a mechanical, electrical, process system, etc. used in the offshore energy area. The set up system should be analysed, and models and simulations of the system are to be made. Different methods are to be applied to find the parameters of the system. The set-up models should be verified by experimental test either directly on a real offshore system or on a model or parts of the scaled systems set up in the laboratory. The project must be documented as described in "Additional Information".

EXTENT AND EXPECTED WORKLOAD

Since it is a 15 ECTS project module, the work load is expected to be 450 hours for the student

EXAM

PREREQUISITE FOR ENROLLMENT FOR THE EXAM

- It is a precondition for students with a bachelor's degree from AAU that they participate in the Conference for MSc Energy Students (CES). Students are obliged to prepare a scientific paper and a poster which must be presented at the conference.

EXAMS

Name of exam	Modelling and Identification of Offshore Systems
Type of exam	Oral exam based on a project
ECTS	15
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Project on 1st Semester Offshore Energy Systems (OES).

Examination format

The exam will be based on the documentation submitted and the rules in "Guidance for the Project of 1st Semester MSc in Sustainable Energy Engineering", see below.

Guidance for the Project of 1st Semester MSc in Sustainable Energy Engineering

(For students with a Bachelor's degree from Aalborg University) (not INTRO)

1. Demands to the project documentation

The project should fulfil the objectives of the 1st semester project theme and should be documented to an acceptable technical and scientific level. The documentation shall include a scientific paper and a poster, which shall fulfil the standard for an international conference, e.g. the IEEE specifications. Moreover, the documentation shall include a project summary report - see below.

2. Project documentation

The following material must be uploaded to the system "Digital Exam" on the date given for the submission:

- Scientific paper, max. 10 pages, which presents the primary content and results of the project work
- Project summary report (see below)
- Project poster

3. Conference participation

The paper must be presented, by one or more group members at a conference arranged within the Department of Energy Technology. The conference will be run in the same manner as an international conference. The project poster must also be presented at this conference. All group members must attend the conference and the poster session to be allowed to participate in the project examination.

4. Project summary report

The project summary report should elaborate the project details and conclusions. The maximum length of the summary report (report without appendices) is 50 pages, and in addition the summary report should follow the rules as laid down by the Study Board in "Procedure for Project Work", i.e. the total number of pages must not exceed $30 + 15 \times$ number of students in the project group.

5. Project exam

The project evaluation will take place at a later date than the conference.

At the project examination the project group shall present its project work in accordance to the Examination Policies and Procedures, Addendum to the Joint Programme Regulations

The presentation and assessment of the project is conducted in English.

FACTS ABOUT THE MODULE

Danish title	Modellering og identifikation af offshore systemer
Module code	N-SEE-K1-2
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	15
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Zhenyu Yang

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

PROBLEM BASED PROJECT ORGANISED LEARNING IN MODELLING AND IDENTIFICATION OF OFFSHORE SYSTEMS (INTRO)

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension of the Problem Based Learning methods, as it is applied at Aalborg University
- Have knowledge and comprehension within the design, analysis and modelling of offshore energy systems or subsystems with complex dynamics and elements with linear and non-linear behaviour
- Have knowledge and comprehension within test design, modelling and identification of components used in offshore energy systems
- Have knowledge and comprehension within modelling of offshore energy systems based on physics as well as data in the form of stochastic systems or processes

SKILLS

- Be able to judge the usefulness of the used different scientific methods for the analysis, modelling, and verification of offshore energy systems and/or components
- Be able to verify the analytical and numerical approaches by means of simple laboratory experiments
- Be able to communicate scientific results by means of a project report and an oral presentation in English.

COMPETENCES

- Be able to control the working and development process within the project theme, and be able to develop new solutions within modelling and identification of offshore systems
- Independently be able to define and analyse scientific problems for modelling and identification of offshore systems, and based on this be able to make and state the reasons for decisions made for instance with respect to their influences on the environment
- Independently be able to continue own development in competence and specialisation

TYPE OF INSTRUCTION

Problem based project oriented project work in groups. During the project period you should be able to plan and structure the project work, work in groups and solve conflicts, use consensus versus fight/voting and see differences among group members as a strength. You should also work with the structure of a project report and prepare a problem formulation, set up project limitation and time schedule. The project should be based on modelling and identification of a simple offshore system. The set-up system should be analysed, and models and simulations of the offshore system are to be made. Different system identification methods are to be applied to find the parameters of the system. The set-up models should be verified by experimental tests, either directly on a real offshore system or on a model, or parts of the systems, set up in the laboratory.

EXTENT AND EXPECTED WORKLOAD

Since it is a 10 ECTS project module, the work load is expected to be 300 hours for the student

EXAM

EXAMS

Name of exam	Problem Based Project Organised Learning in Modelling and Identification of Offshore Systems
Type of exam	Oral exam based on a project
ECTS	10
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Project on 1st Semester INTRO of Offshore Energy Systems (OES).

FACTS ABOUT THE MODULE

Danish title	Problembaseret projektorganiseret læring i modellering og identificering af offshore systemer (INTRO)
Module code	N-SEE-K1-5
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	10
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Zhenyu Yang

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

SYSTEM IDENTIFICATION AND DIAGNOSIS

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

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.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	System Identification and Diagnosis
Type of exam	Oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

This course is taught to the 1st semester MSc students at the Offshore Energy Systems specialisation and is offered as an elective course at the 3rd semester of the Energy Engineering specialisations as well as the Process Engineering and

Combustion Technology specialisation. Students of the Offshore Energy Systems specialisation cannot elect the module again.

FACTS ABOUT THE MODULE

Danish title	Systemidentifikation og diagnosticering
Module code	N-SEE-K1-3
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg, Campus Aalborg
Responsible for the module	Zhenyu Yang , Per Johansen , Seyed Mohsen Nourbakhsh Soltani

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

FLUID AND WATER WAVE DYNAMICS

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about fluid kinematics
- Have knowledge about stresses in fluids, equation of motion, constitutive models and Navier-Stokes equations
- Have knowledge about ideal fluids and potential flows, including application of potential theory to simple problems for example circular cylinder and calculation of hydrodynamic mass
- Have knowledge and understanding of Reynolds averaging and turbulence models
- Be able to describe turbulent and laminar boundary layers including understanding of momentum equation for boundary layers
- Be able to describe wind generated waves
- Understand the application of potential theory to linear surface waves on a horizontal bed, including description and linearisation of boundary conditions, solving Laplace equation and the dispersion equation
- Have knowledge about kinematic and dynamic descriptions of linear surface waves, including particle velocities and accelerations, pressure field, particle paths, wave energy, energy flux and group velocity
- Be able to describe waves in shallow water, i.e. shoaling, refraction, diffraction and wave breaking
- Have knowledge about statistical description of waves in time and frequency domain

SKILLS

- Be able to describe assumptions and limitations of mathematical models for different types of flows
- Be able to apply analytical and semi-empirical methods for mathematical description of fluid dynamic problems
- Be able to calculate kinematics and dynamics of regular linear waves on deep and shallow water
- Be able to analyse irregular waves in time and frequency domain

COMPETENCES

- Be able to apply proper terminology in oral, written and graphical communication and documentation within fluid and water wave dynamics

TYPE OF INSTRUCTION

Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Fluid and Water Wave Dynamics
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination

Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/
------------------------	--

FACTS ABOUT THE MODULE

Danish title	Strømningslære og bølgehydraulik
Module code	N-SEE-K1-6
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Matthias Mandø

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

PROBABILITY THEORY, STOCHASTIC PROCESSES AND APPLIED STATISTICS

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about fundamental concepts in probability, including conditional probability and independence
- Have knowledge about discrete and continuous random variables and relevant properties of these
- Have knowledge about various examples of descriptive statistics and graphics, e.g. histograms, boxplots, scatterplots, lag plots and auto covariance plots
- Have knowledge about statistical inference, including estimation, confidence intervals and hypothesis testing
- Have knowledge about basic concepts related to stochastic processes such as stationarity, correlation function and spectral density
- Have elementary knowledge about wiener processes, white noise and linear stochastic differential equations
- Have comprehension of a concrete example of a model for a simple stochastic process

SKILLS

- Be able, given specific data, to specify a relevant statistical model and account for the assumptions and limitations of the chosen model
- Be able to use relevant software for carrying out the statistical analysis of given data and be able to interpret the results of the analysis
- Be able to use statistical models, like linear regression (simple and multiple) and analysis of variance

COMPETENCES

- Be able to judge the applicability of statistics within own area
- Be capable of performing a critical evaluation of the results of a statistical analysis
- Be capable of communicating the results of a statistical analysis to people with no or little background within statistics.

TYPE OF INSTRUCTION

Lectures in combination with practical exercises and self-study or similar.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Probability Theory, Stochastic Processes and Applied Statistics
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination

Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/
------------------------	--

FACTS ABOUT THE MODULE

Danish title	Sandsynlighedsregning, stokastiske processer og anvendt statistik
Module code	N-EE-K1-12
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	John Vestergaard Olesen , Jan Otto Hooghoudt

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

CONTROL THEORY AND MATLAB (INTRO)

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Be able to comprehend time-domain analysis of continuous-time systems
- Be able to comprehend frequency response analysis of continuous-time systems
- Be able to apply the basic rules in discrete control theory including having knowledge about sampling systems, zero-order-hold and the influence of time delays
- Have knowledge and comprehension within the basic features of MATLAB as a programming language

SKILLS

- Be able to analyse and to design time-invariant linear continuous-time control systems using classical methods
- Be able to analyse different design and compensation methods in control engineering
- Be able to apply discrete equivalents for continuous transfer functions
- Be able to analyse, design and implement digital control systems
- Be able to use commercial simulation software as a control system design tool
- Be able to use the simple plotting facilities in MATLAB
- Be able to use data analysis routines in MATLAB

COMPETENCES

- Independently be able to define and analyse scientific problems

TYPE OF INSTRUCTION

The course will be taught by a mixture of lectures, workshops, exercises, mini-projects and self-study.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student

EXAM

EXAMS

Name of exam	Control Theory and MATLAB
Type of exam	Written exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Common for students with a Bachelor's degree from another university than Aalborg University.

FACTS ABOUT THE MODULE

Danish title	Reguleringsteori og MATLAB (INTRO)
Module code	N-EE-K1-13
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Seyed Mohsen Nourbakhsh Soltani , Henrik Clemmensen Pedersen

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

DYNAMIC CONTROL OF OFFSHORE ELECTRICAL SYSTEMS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 1st semester on the Master of Science in Sustainable Energy Engineering with specialisation in Offshore Energy Systems or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension within how to design, analyse and model offshore energy systems and the relationship between the used components
- Have knowledge and comprehension within electrical machines and/or power converters used for offshore energy systems
- Have knowledge and comprehension within control of electrical machines, compressors, pumps, thermal, or hydraulic machines, etc., used for offshore energy systems

SKILLS

- Be able to judge the usefulness of the different scientific methods for analysis and modelling of the offshore energy systems
- Be able to design advanced control systems to improve the performance and the energy efficiency of the different offshore energy systems
- Be able to verify the analytical and numerical approaches by means of laboratory experiments

COMPETENCES

- Be able to control the working and development process within the project theme, and be able to develop new solutions within offshore energy systems
- Independently be able to define and analyse scientific problems in the area of offshore energy systems, and based on that make and state the reasons for decisions made
- Independently be able to continue own development in competence and specialisation

TYPE OF INSTRUCTION

Problem based project-oriented project work in groups. The project should be based on an offshore energy system which includes fluid power, electrical, mechanical and/or thermal etc. components to be modelled, analysed and controlled. This could e.g. be a wave energy system, offshore oil & gas, offshore wind turbines, or their subsystems, etc. The systems should be analysed and a mathematical simulation model should be developed for the system. Based on the model, the system is analysed with regard to efficiency, technology choices and technology interaction. The analysis is the basis for setting up a control system and making a design or redesign of the system, or selected parts hereof. The design may take its basis in the existing system (optimised redesign) or may include new solutions or designs and control methods. In both cases emphasis is placed on the fact that the system is improved with regard to efficiency and system performance. The developed design and control method, or the essential parts hereof, may be experimentally verified, either in model scale or on the real system, if possible.

EXTENT AND EXPECTED WORKLOAD

Since it is a 15 ECTS project module, the work load is expected to be 450 hours for the student

EXAM**EXAMS**

Name of exam	Dynamic Control of Offshore Electrical Systems
Type of exam	Oral exam based on a project
ECTS	15
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Project on 2nd Semester Offshore Energy Systems (OES).

FACTS ABOUT THE MODULE

Danish title	Dynamisk styring af elektriske offshore systemer
Module code	N-SEE-K2-2
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	15
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Seyed Mohsen Nourbakhsh Soltani
Time allocation for external examiners	B

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

OFFSHORE ENERGY SYSTEM TECHNOLOGY

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about offshore wind/wave energy systems, modelling and simulation tools for offshore wind turbine and wind farm design
- Have comprehension of drilling technology, reservoir theory, extraction principles for oil and gasses and enhanced oil recovery methods

SKILLS

- Independently be able to define and analyse scientific problems involving offshore energy systems/subsystems
- Be able to analyse methods for design and control of offshore wind farms and power plants
- Be able to judge the usefulness of the set up methods for the drilling technology, the reservoir theory and different extraction principles
- Be able to relate the methods to applications in industry

COMPETENCES

- Independently be able to be a part of professional and interdisciplinary development work within offshore energy systems

TYPE OF INSTRUCTION

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

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student

EXAM

EXAMS

Name of exam	Offshore Energy System Technology
Type of exam	Oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Offshore energisystemer
--------------	-------------------------

Module code	N-SEE-K2-5
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Seyed Mohsen Nourbakhsh Soltani

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

CONTROL AND SURVEILLANCE OF PROCESSES AND SYSTEMS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved in Control theory and digital microprocessors.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have comprehension of some typical industrial automation processes or systems including PLC systems and SCADA systems
- Have comprehension of fundamental concepts and terms of non-linear systems and non-linear control theory
- Have comprehension of Lyapunov's methods for stability analysis and non-linear control theory

SKILLS

- Be able to use basic mathematical tools for analysing the response and stability of non-linear systems
- Be able to apply the acquired knowledge to handle some small-sized industrial automation systems
- Be able to apply selected methods for non-linear control design
- Be able to judge the usefulness of the applied methods
- Be able to relate the methods to applications in industry

COMPETENCES

- Independently be able to define and analyse scientific problems within the area of control and surveillance systems
- Independently be able to be a part of professional and interdisciplinary development work within the area of control and surveillance systems

TYPE OF INSTRUCTION

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

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student

EXAM

EXAMS

Name of exam	Control and Surveillance of Processes and Systems
Type of exam	Oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination

Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/
------------------------	--

FACTS ABOUT THE MODULE

Danish title	Regulerings- og overvågningsprocesser og –systemer
Module code	N-SEE-K2-6
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Seyed Mohsen Nourbakhsh Soltani

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

DYNAMIC MODELLING OF ELECTRICAL MACHINES AND CONTROL SYSTEMS

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Be able to comprehend dynamic models of the transformer, DC Motor, the synchronous machine and the induction machine
- Have knowledge about the limitations for a dynamic model of an electrical machine
- Control principles of DC motors
- Have knowledge about AC machines and space vectors
- Comprehension of techniques for scalar variable-speed control of induction machines
- Knowledge about implementation of different controllers for variable-speed AC-drives
- Knowledge about basic non-linear control theory and its application of electrical machine drives

SKILLS

- Independently be able to define and analyse scientific problems involving a dynamic model of an electrical machine
- Be able to analyse and design scalar and vector controllers for electrical drives
- Be able to apply selected linear and non-linear control methods for electrical drives

COMPETENCES

- Independently be able to define and analyse scientific problems involving a dynamic model of an electrical machine
- Be able to analyse and design scalar and vector controllers for electrical drives
- Be able to apply selected linear and non-linear control methods for electrical drives

TYPE OF INSTRUCTION

The course will be taught by a mixture of lectures, workshops, exercises, mini-projects and self-study.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student

EXAM

EXAMS

Name of exam	Dynamic Modelling of Electrical Machines and Control Systems
Type of exam	Written exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations.

<http://www.engineering.aau.dk/uddannelse/studieadministration/>

FACTS ABOUT THE MODULE

Danish title	Dynamiske modeller for elektriske maskiner og regulering
Module code	N-SEE-K2-7
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Amin Hajizadeh

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

ADVANCED CONTROL OF OFFSHORE ENERGY SYSTEMS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 2nd semester at the Master of Science in Sustainable Energy Engineering with specialisation in Offshore Energy Systems or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension within how to design control, diagnostic and/or surveillance systems for offshore energy systems
- Have knowledge and comprehension within different advanced control methods

SKILLS

- Be able to judge the usefulness of the different scientific methods for the design of control, diagnostic and/or surveillance systems for offshore energy systems
- Be able to verify the different scientific analysis and methods by laboratory experiments

COMPETENCES

- Be able to control the working and development process within the project theme, and be able to develop new solutions within control, diagnostic and/or surveillance of offshore energy systems
- Be able to show entrepreneurship to define and analyse scientific problems in the area of control, diagnostic and/or surveillance of offshore energy systems, and based on that make and state the reasons for decisions made
- Be able to set up innovative ideas within the area of control, diagnostic and/or surveillance of offshore energy systems
- Independently be able to continue own development in competence and specialisation
- Be able to follow more sophisticated literature, or state-of-the-art, within control, diagnostic and/or surveillance of offshore energy systems

TYPE OF INSTRUCTION

Problem based project-oriented project work in groups. The project work must be documented by a scientific paper (max. 8 pages). If judged necessary, this paper may be accompanied by a project summary report. The project summary report should elaborate the project details and conclusions. The maximum length of the summary report (report without appendices) is 50 pages, and in addition the summary report should follow the rules as laid down by the Study Board in "Procedure for Project Work", i.e. the total number of pages must not exceed $30 + 15 \times$ number of students in the project group. The project work will consider advanced control, optimisation or diagnostic or surveillance systems for off-shore energy systems. Based on a model, the advanced control-, diagnostic or surveillance system is set up to improve the performance of the system, either with regard to power output, energy efficiency, life time extraction, fault detections, etc. The system should be implemented and verified experimentally. Due to special technical or scientific documentation requirements, the student documents the project work in a project report, which can be prepared individually or in a group within the project theme; however the student's special preferences for the semester must be approved by the Study Board in advance.

EXTENT AND EXPECTED WORKLOAD

Since it is a 20 ECTS project module, the work load is expected to be 600 hours for the student

EXAM

PREREQUISITE FOR ENROLLMENT FOR THE EXAM

- It is a pre-condition that the student has submitted a scientific article and presented the scientific article at the CES conference prior to the project examination. All group members must be present at the conference.

EXAMS

Name of exam	Advanced Control of Offshore Energy Systems
Type of exam	Oral exam based on a project The project group should orally present the project work and scientific paper as specified in the Examination Policies and Procedures, Addendum to the Joint Programme Regulations. The project group members will undergo an oral examination with internal adjudicator, based on the scientific paper and the project summary report.
ECTS	20
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Project on 3rd Semester Offshore Energy Systems.

The student may follow a relevant study as a guest student (30 ECTS) at another university in Denmark or abroad, see details in Moodle. However, the student's special preferences for the semester must be approved by the Study Board in advance.

FACTS ABOUT THE MODULE

Danish title	Avanceret regulering af offshore energisystemer
Module code	N-SEE-K3-2
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	20
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Zhenyu Yang

ORGANISATION

Study Board	Study Board of Energy
-------------	-----------------------

Curriculum for the Master of Science (MSc) Programme in Sustainable Energy Engineering 2017

Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

VOLUNTARY TRAINEESHIP

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the previous semesters on the Master of Science in Energy Engineering, the Master of Science in Sustainable Energy Engineering, or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about analytical, numerical and/or experimental methods for analysis of advanced tasks within the field of the external organisation
- Understand the connection between theory and practice
- Have knowledge about the organisational structure and the work of an organisation seen from an engineering/managerial perspective

SKILLS

- Be able to apply analytical, numerical and/or experimental methods for analysis and solving of advanced tasks within the field of the external organisation
- Be able to compare and evaluate assumptions, limitations and uncertainties related to the methods applied in connection to finding solutions of advanced challenges within the field of the external organisation

COMPETENCES

- Be able to handle development-oriented situations in connection to either studying or working
- Be able to use the correct terminology in oral, written or graphical communication and documentation of challenges and solutions within the field of the external organisation
- Be able to analyse the academic, professional and social benefits of the traineeship
- Be able to communicate these results in a project report and/or a case-based project report
- Be able to evaluate the learning result of the traineeship

TYPE OF INSTRUCTION

The student works in a company providing experience in solving advanced and relevant engineering tasks on a level corresponding to the study programme's 3rd semester and with a progression in the degree of difficulty of the tasks during the period. The type of work must allow for an academic report to be made. The student writes either a project report or a case-based project report within the theme of the 3rd semester of the specialisation, cf. "Guidelines for Project Work in an External Organisation (Voluntary Traineeship)" laid down by the School of Engineering and Science.

EXTENT AND EXPECTED WORKLOAD

Since it is a 30 ECTS project module, the work load is expected to be 900 hours for the student.

EXAM

EXAMS

Name of exam	Voluntary Traineeship
Type of exam	Oral exam based on a project

	An oral and individual examination based on either the project report or the case-based project report.
ECTS	30
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Instead of doing the project work and the elective courses, the student can do project work in a company as an individual or as a part of a group. See details in Moodle. However, the student's special preferences for the semester must be approved by the Study Board in advance.

FACTS ABOUT THE MODULE

Danish title	Projektorienteret forløb i en virksomhed
Module code	N-EE-K3-7
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	30
Language of instruction	English
Location of the lecture	Other location
Responsible for the module	Tamas Kerekes , Chungen Yin , Henrik Clemmensen Pedersen , Filipe Miguel Faria da Silva , Kaiyuan Lu

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

MASTER'S THESIS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 3rd semester on the Master of Science in Sustainable Energy Engineering with specialisation in Offshore Energy Systems or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension within the area of offshore energy systems at the highest international level
- Be able to critically judge knowledge and identify new scientific problems within the area of offshore energy systems
- Have comprehension of the implications within the research work (research ethics)

SKILLS

- Be able to judge the usefulness of different scientific methods and tools for analysis and problem solving within the field of offshore energy systems
- Be able to use advanced laboratory set-ups, data analysis methods and analysis and modelling methods within the field of offshore energy systems
- Be able to communicate scientific problems both to specialists and the public
- Have obtained skills related to the industrial area within offshore energy systems

COMPETENCES

- Be able to control complex or unexpected working and development situations within offshore energy systems, and be able to develop new solutions
- Independently be able to define and analyse scientific problems, and based on that make and state the reasons for decisions made
- Independently be able to continue own development in competence and specialisation
- Independently be able to be the head of professional and interdisciplinary development work and be able to undertake the professional responsibility

TYPE OF INSTRUCTION

Problem based project oriented project work. The final project may study new subjects or be an extension of the project work from previous semesters. The subject matter will remain in the area of offshore energy systems. The project may be of theoretical or experimental nature and will often be in collaboration with an industrial company or other research institution performing research in the area of offshore energy systems.

EXTENT AND EXPECTED WORKLOAD

Since it is a 30 ECTS project module, the work load is expected to be 900 hours for the student

EXAM

EXAMS

Name of exam	Master's Thesis
--------------	-----------------

Type of exam	Oral exam based on a project
ECTS	30
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Kandidatspeciale
Module code	N-SEE-K4-2
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	30
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Zhenyu Yang
Time allocation for external examiners	D

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

MASTER'S THESIS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying all previous semesters on the Master of Science in Sustainable Energy Engineering with specialisation in Offshore Energy Systems or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension within the area of offshore energy systems at the highest international level
- Be able to critically judge knowledge and identify new scientific problems within the area of offshore energy systems
- Have comprehension of the implications within the research work (research ethics)

SKILLS

- Be able to judge the usefulness of different scientific methods and tools for analysis and problem solving within the field of offshore energy systems
- Be able to use advanced laboratory set-ups, data analysis methods and analysis and modelling methods within the field of offshore energy systems
- Be able to communicate scientific problems both to specialists and the public
- Have obtained skills related to the industrial area within offshore energy systems

COMPETENCES

- Be able to control complex or unexpected working and development situations within offshore energy systems, and be able to develop new solutions
- Independently be able to define and analyse scientific problems, and based on that make and state the reasons for decisions made
- Independently be able to continue own development in competence and specialisation
- Independently be able to be the head of professional and interdisciplinary development work and be able to undertake the professional responsibility

TYPE OF INSTRUCTION

Problem based project oriented project work. The final project may study new subjects or be an extension of the project work from previous semesters. The subject matter will remain in the area of offshore energy systems. The project may be of theoretical or experimental nature and will often be in collaboration with an industrial company or other research institution performing research in the area of offshore energy systems.

EXTENT AND EXPECTED WORKLOAD

Since it is a 50 ECTS project module, the work load is expected to be 1500 hours for the student

EXAM

EXAMS

Name of exam	Master's Thesis
--------------	-----------------

Type of exam	Oral exam based on a project
ECTS	50
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

The Master's Thesis is conducted as a long Master's Thesis using both the 3rd and 4th semesters. The long Master's Thesis must include experimental work and must be approved by the Study Board in advance. The amount of experimental work must reflect the allotted ECTS.

FACTS ABOUT THE MODULE

Danish title	Kandidatspeciale
Module code	N-SEE-K4-2LG
Module type	Project
Duration	2 semesters
Semester	Autumn
ECTS	50
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Zhenyu Yang
Time allocation for external examiners	D

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

FLUID MECHANICAL ANALYSIS METHODS

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension within analytical, numerical and experimental analysis methodology for fluid flow
- Have knowledge and comprehension within the flow around or within simplified components

SKILLS

- Be able to verify analytical and numerical approaches by means of simple laboratory experiments
- Be able to document the project work as a scientific paper and poster

COMPETENCES

- Be able to control the working and development process within the project theme, and be able to develop new solutions within fluid mechanical analysis methods
- Be able to define and analyse, in an independent manner, scientific problems within the area of fluid mechanical methods, and based on that make and state the reasons for decisions made

TYPE OF INSTRUCTION

Problem based project oriented project work in groups. The project should be based upon a simple fluid flow problem. The problem should be investigated using analytical, numerical and experimental methods. The problem can be a process or a typical engineering component which involves single phase fluid flow of a stationary or a transient nature. The project should involve the Computational Fluid Dynamics (CFD) simulation of the simple fluid flow problem. The simulation should be verified by laboratory experiments and the validity of any assumptions made should be checked.

The purpose of the project may be:

- To analyse the performance of an engineering component
- To investigate the validity of empirical expressions or
- To conduct parameter variations on a design or similar

The project must be documented as described under "Additional Information".

EXTENT AND EXPECTED WORKLOAD

Since it is a 15 ECTS project module, the work load is expected to be 450 hours for the student

EXAM

PREREQUISITE FOR ENROLLMENT FOR THE EXAM

- It is a precondition for students with a bachelor's degree from AAU that they participate in the Conference for MSc Energy Students (CES). Students are obliged to prepare a scientific paper and a poster which must be presented at the conference.

EXAMS

Name of exam	Fluid-Mechanical Analysis Methods
--------------	-----------------------------------

Type of exam	Oral exam based on a project
ECTS	15
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Examination format

The exam will be based on the documentation submitted and the rules in "Guidance for the Project of 1st Semester MSc in Sustainable Energy Engineering", see below.

This project module is common for students with a Bachelor's degree from Aalborg University heading for the specialisations in Thermal Energy and Process Engineering (TEPE), Fuel Cells and Hydrogen Technology (HYTEC) and Process Engineering and Combustion Technology (PECT).

Guidance for the Project of 1st Semester MSc in Energy Engineering (For students with a Bachelor's degree from Aalborg University) (not INTRO)

1. Demands to the project documentation

The project should fulfil the objectives of the 1st semester project theme and should be documented to an acceptable technical and scientific level. The documentation shall include a scientific paper and a poster, which shall fulfil the standard for an international conference, e.g. the IEEE specifications. Moreover, the documentation shall include a project summary report - see below.

2. Project documentation

The following material must be uploaded to the system "Digital Exam" on the date given for the submission:

- Scientific paper, max. 10 pages, which presents the primary content and results of the project work
- Project summary report (see below)
- Project poster

3. Conference participation

The paper must be presented, by one or more group members at a conference arranged within the Department of Energy Technology. The conference will be run in the same manner as an international conference. The project poster must also be presented at this conference. All group members must attend the conference and the poster session to be allowed to participate in the project examination.

4. Project summary report

The project summary report should elaborate the project details and conclusions. **The maximum length of the summary report (report without appendices) is 50 pages**, and in addition the summary report should follow the rules as laid down by the Study Board in "Procedure for Project Work", i.e. the total number of pages must not exceed 30 + 15 × number of students in the project group.

5. Project exam

The project evaluation will take place at a later date than the conference.

At the project examination the project group shall present its project work in accordance to the Examination Policies and Procedures, Addendum to the Joint Programme Regulations

The presentation and assessment of the project is conducted in English.

FACTS ABOUT THE MODULE

Danish title	Fluidmekaniske analysemetoder
Module code	N-EE-K1-1
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	15
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Henrik Sørensen

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

PROBLEM BASED PROJECT ORGANISED LEARNING IN COMBUSTION TECHNOLOGY (INTRO)

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension within the Problem Based Learning methods, as it is applied at Aalborg University
- Have knowledge and comprehension within analytical, numerical and experimental analysis methodology for fluid flow
- Have knowledge and comprehension within the flow around or within simplified components

SKILLS

- Be able to verify the analytical and numerical approaches by means of simple laboratory experiments
- Be able to communicate scientific results by means of a project report and an oral presentation in English
- Be able to structure and plan PBL based project work and writing

COMPETENCES

- Be able to control the working and development process within the project theme, and be able to develop new solutions within fluid mechanical analysis methods
- Be able to define and analyse, in an independent manner, scientific problems within the area of fluid mechanical methods, and based on that make and state the reasons for decisions made
- Be able to continue, in an independent manner, their own development in competence and specialisation

TYPE OF INSTRUCTION

Problem based project oriented project work in groups. During the project period you should be able to plan and structure the project work, work in groups and solve conflicts, use consensus versus fight/voting and see differences among group members as a strength. You should also work with the structure of a project report and prepare a problem formulation, set up project limitation and time schedule. The project should contain a detailed analysis of a simple flow situation or combustion process. The analysis should include a numerical analysis which can be compared to relevant flow or combustion theory. The calculations should be verified by laboratory experiments. The validity of any assumptions made should be checked. The project should be based upon a problem which has its origins in thermal energy engineering. The problem should typically include a thermal energy conversion process and/or a fluid flow component.

EXTENT AND EXPECTED WORKLOAD

Since it is a 10 ECTS project module, the work load is expected to be 300 hours for the student

EXAM

EXAMS

Name of exam	Problem Based Project organised Learning in Combustion Technology
Type of exam	Oral exam based on a project
ECTS	10

Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Project on 1st INTRO Semester of Process Engineering and Combustion Technology (PECT).

For students with a Bachelor's degree from another university than Aalborg University heading for the specialisation in Process Engineering and Combustion Technology (PECT).

FACTS ABOUT THE MODULE

Danish title	Problembaseret projektorganiseret læring i forbrændingsteknik (INTRO)
Module code	N-SEE-K1-4
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	10
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Matthias Mandø

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

COMPUTATIONAL FLUID DYNAMICS (CFD) AND MULTIPHASE FLOW

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about the methods behind Computational Fluid Dynamics (CFD)
- Have knowledge about various spatial and temporal discretisation schemes
- Have knowledge about the pressure-velocity coupling method for solving the Navier-Stokes equations numerically
- Have knowledge about meshing strategies and boundary conditions
- Have knowledge about the fundamentals of turbulence, the energy cascade and Kolmogorov hypotheses
- Have knowledge and understanding within Reynolds-Averaged Navier-Stokes (RANS) and turbulence modelling
- Have knowledge about the fundamentals of multiphase flow
- Have knowledge about different modelling approaches for multiphase flow and multiphase models in the context of CFD
- Have knowledge about turbulence-particle interaction in multiphase flow

SKILLS

- Be able to use the finite volume method to numerically solve simple problems
- Be able to perform a mesh independency study in CFD analyses
- Be able to perform CFD analyses of a turbulent flow with regards to selection of turbulence model and near wall modelling/meshing strategy
- Be able to perform CFD analyses for non-reacting multiphase flow, for both the Euler-Euler and Euler-Lagrange approaches
- Be able to apply proper terminology in oral, written and graphical communication and documentation within CFD, turbulence and multiphase flows

COMPETENCES

- Be able to use the finite volume method to numerically solve simple problems
- Be able to perform a mesh independency study in CFD analyses
- Be able to perform CFD analyses of a turbulent flow with regards to selection of turbulence model and near wall modelling/meshing strategy
- Be able to perform CFD analyses for non-reacting multiphase flow, for both the Euler-Euler and Euler-Lagrange approaches
- Be able to apply proper terminology in oral, written and graphical communication and documentation within CFD, turbulence and multiphase flows

TYPE OF INSTRUCTION

Lectures supplemented by workshops, exercises, hands-on and self-studies.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM**EXAMS**

Name of exam	Computational Fluid Dynamics (CFD) and Multiphase Flow
Type of exam	Oral exam Oral examination which can be based on a mini-project.
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Numerisk strømningslære (CFD) og flerfasestrømning
Module code	N-EE-K1-7
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Chungen Yin

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

FLUID MECHANICS AND COMPRESSIBLE FLOW

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about fluid kinematics
- Have knowledge about stresses in fluids, equation of motion, constitutive models and Navier-Stokes equations
- Have knowledge about ideal fluids and potential flows, including application of potential theory to simple problems
- Have knowledge and comprehension within the fundamentals of gas dynamics and compressible flow
- Have knowledge about steady and unsteady shock wave phenomena in compressible flow
- Have knowledge about aerofoil performance in compressible flows

SKILLS

- Be able to describe assumptions and limitations of mathematical models for different types of flows
- Be able to apply appropriate analytical and semi-empirical models for mathematical description of fluid dynamic problems
- Be able to describe turbulent and laminar boundary layers including understanding of the momentum integral equation for boundary layers
- Be able to apply appropriate analytical and numerical method techniques to gas dynamics and compressible flows
- Be able to apply proper terminology in oral, written and graphical communication and documentation within fluid dynamics
- Be able to apply the topic of the module in multi-disciplinary contexts

COMPETENCES

- Be able to describe assumptions and limitations of mathematical models for different types of flows
- Be able to apply appropriate analytical and semi-empirical models for mathematical description of fluid dynamic problems
- Be able to describe turbulent and laminar boundary layers including understanding of the momentum integral equation for boundary layers
- Be able to apply appropriate analytical and numerical method techniques to gas dynamics and compressible flows
- Be able to apply proper terminology in oral, written and graphical communication and documentation within fluid dynamics
- Be able to apply the topic of the module in multi-disciplinary contexts

TYPE OF INSTRUCTION

Lectures supplemented by workshops, exercises, self-studies and study groups.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Fluid Mechanics and Compressible Flow
Type of exam	Oral exam

ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Fluidmekanik og kompressible strømninger
Module code	N-EE-K1-8
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Thomas Joseph Condra , Matthias Mandø

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

COMBUSTION AND/OR PROCESS SYSTEMS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 1st semester on the Master of Science in Sustainable Energy Engineering with specialisation in Process Engineering and Combustion Technology or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and understanding within process and/or combustion systems, their components and the interaction between these
- Have knowledge about the design, modelling and optimisation of the individual components comprising process and/or combustion systems
- Have knowledge and comprehension within the multiphase and chemical reaction aspects involved in process and/or combustion systems

SKILLS

- Be able to judge the usefulness of different scientific methods used for the analysis, modelling and simulation of process and/or combustion systems
- Be able to verify the analytical and numerical approaches by means of experimental data
- Be able to manage the problem based work and development process within the project theme
- Be able to independently define and analyse scientific problems within the topic of process and/or combustion and to propose and develop solutions for the present problem
- Be able to independently continue own development in competence and specialisation

COMPETENCES

- Be able to judge the usefulness of different scientific methods used for the analysis, modelling and simulation of process and/or combustion systems
- Be able to verify the analytical and numerical approaches by means of experimental data
- Be able to manage the problem based work and development process within the project theme
- Be able to independently define and analyse scientific problems within the topic of process and/or combustion and to propose and develop solutions for the present problem
- Be able to independently continue own development in competence and specialisation

TYPE OF INSTRUCTION

Problem based project oriented project work in groups. The project should be based on a combustion or process system which involves aspects of either multiphase flow and/or chemical reactions. The project should involve simulation of a combustion or process system or part thereof. Tools such as numerical optimisation, Computational Fluid Dynamics, process simulation or similar should be applied. The project could be based on a steady state process, operational variations or transient problems arising from start-up and shut down of combustion and/or process facilities. The results obtained from analysis, modelling or simulations should be attempted to be verified by laboratory experiments or existing process data from a plant.

EXTENT AND EXPECTED WORKLOAD

Since it is a 15 ECTS project module, the work load is expected to be 450 hours for the student

EXAM

EXAMS

Name of exam	Combustion and/or Process Systems
Type of exam	Oral exam based on a project
ECTS	15
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Project on 2nd Semester Process Engineering and Combustion Technology (PECT).

FACTS ABOUT THE MODULE

Danish title	Forbrændings- og/eller processystemer
Module code	N-SEE-K2-1
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	15
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Jens Bo Holm-Nielsen
Time allocation for external examiners	B

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

PROCESS SIMULATION

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about the principles of process simulation
- Have knowledge about process optimisation using process simulation
- Have knowledge about computational aspects of phase equilibria
- Have knowledge about instrumentation and PFD & PID's
- Have knowledge about commercial process simulators

SKILLS

- Be able to illustrate an actual process in a PFD
- Be able to convert a PFD into a working process simulation
- Be able to perform both steady-state and dynamic simulations

COMPETENCES

- Be able to investigate a given case using simulation tools
- Be able to select an appropriate thermodynamic model for a given case

TYPE OF INSTRUCTION

Mainly via lectures, supplemented by workshops, exercises, hands-on and self-study.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student

EXAM

EXAMS

Name of exam	Process Simulation
Type of exam	Written and oral exam Oral examination based on a mini project.
ECTS	5
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Processimulering
--------------	------------------

Module code	N-SEE-K2-3
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Birgitte Bak-Jensen

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

COMBUSTION TECHNOLOGY AND CHEMICAL REACTORS

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about the technologies used within emission control and how chemical kinetics influences combustion processes
- Understand the analytical methods used in the analysis of combustion flames
- Understand the analytical methods used in processes involving simultaneous heat and mass transfer
- Understand the terminologies and notations used in fundamental chemical reactor analysis.
- Understand how mixing affects the conversion in actual chemical reactors
- Understand how catalysts are practically arranged and supported in various types of chemical reactors and understand how this affects the overall performance parameters

SKILLS

- Be able to use software used in combustion analysis
- Be able to calculate chemical compositions arising from kinetically controlled chemical re-actions considering chemical mechanisms and the Arrhenius equation
- Understand the analytical methods used in the analysis of combustion flames
- Be able to design fundamental emission control systems
- Be able to design and model the fundamental classes of chemical reactors, i.e. plug flow reactors, constantly stirred reactors and batch reactors with one and multiply simultaneous reactions considering chemical kinetics in one and multiple dimensions, isothermally or non-isothermally as well as in steady and unsteady operation
- Be able to calculate mass convection and diffusion and perform fundamental analysis on processes involving combined heat and mass transfer processes
- Be able to estimate the mass transport in porous materials
- Have the ability to apply and integrate the topics in an interdisciplinary correspondence with other related disciplines
- Be able to understand the assumptions of the fundamental design of chemical reactors and combined heat and mass transfer

COMPETENCES

- Be able to use software used in combustion analysis
- Be able to calculate chemical compositions arising from kinetically controlled chemical re-actions considering chemical mechanisms and the Arrhenius equation
- Understand the analytical methods used in the analysis of combustion flames
- Be able to design fundamental emission control systems
- Be able to design and model the fundamental classes of chemical reactors, i.e. plug flow reactors, constantly stirred reactors and batch reactors with one and multiply simultaneous reactions considering chemical kinetics in one and multiple dimensions, isothermally or non-isothermally as well as in steady and unsteady operation
- Be able to calculate mass convection and diffusion and perform fundamental analysis on processes involving combined heat and mass transfer processes
- Be able to estimate the mass transport in porous materials
- Have the ability to apply and integrate the topics in an interdisciplinary correspondence with other related disciplines
- Be able to understand the assumptions of the fundamental design of chemical reactors and combined heat and mass transfer

TYPE OF INSTRUCTION

Mainly via lectures, supplemented by workshops, exercises, hands-on and self-study.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student

EXAM

EXAMS

Name of exam	Combustion Technology and Chemical Reactors
Type of exam	Oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Forbrændingsteknik og kemiske reaktorer
Module code	N-SEE-K2-4
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Mette Hedegaard Thomsen

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

OPTIMISATION THEORY AND RELIABILITY

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved in Probability Theory, Stochastic Processes and Applied Statistics on 1st semester of Master of Science study programme in Energy Engineering, Master of Science study programme in Sustainable Energy Engineering, or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have comprehension of the fundamental concepts, terms and methods used within optimisation
- Have comprehension of the fundamental concepts, terms and typical methods used within numerical optimisation of linear and nonlinear optimisation problems
- Have gained an in-depth understanding of important concepts and methods of optimisation for efficient solution of optimisation problems within different areas of engineering
- Have comprehension of how to apply reliability and robust design approach during product development
- Understand statistics that support robustness and reliability
- Have knowledge about cost of poor quality in a product lifetime
- Be able to establish mission profile for different applications and use it into the useful reliability context
- Understand difference between preventive scheduled maintenance or by degradation
- Have comprehension of stressor components like temperature, humidity, vibration and their impact
- Be able to model and determine life-time of components
- Understand physics of failure approach and also failure mechanism – both in normal operations and beyond
- Have knowledge about qualitative and quantitative test methods for reliability assessment
- Have knowledge about prognostic methods and real-time monitoring in power electronic 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 multidimensional functions with constraints
- Be able to solve multiobjective optimisation problems
- Be able understand how designs fit into the robustness validation concept
- Be able to set up simple methods for reliability targets and field analysis
- Be able to set up lifetime requirement at function level or component level
- Have knowledge of how to use test methods for reliability and robustness assessment

COMPETENCES

- Be able to account for the considerations involved in the process of formulating and solving engineering optimisation problems, choosing an advantageous method of solution and implementing it in practice.
- Be able to build a system reliability model
- Set up design limits in respect to reliability
- Be able to specify test procedures for new product development

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 maybe accompanied by an elaboration of the roles of the participants. 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
- project work
- workshops
- exercises (individually and in groups)
- teacher feedback
- reflection
- portfolio work
- study circle
- self-study

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Optimisation Theory and Reliability
Type of exam	Written exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Optimeringsteori og pålidelighedsteori
Module code	N-EE-K2-13
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Henrik Clemmensen Pedersen , Huai Wang

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

ADVANCED COMBUSTION AND PROCESS SYSTEMS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 2nd semester at the Master of Science in Sustainable Energy Engineering with specialisation in Process Engineering and Combustion Technology or similar

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Knowledge and understanding within advanced aspects of process and combustion systems
- Knowledge about advanced models, tools and methods applied for process and combustion systems

SKILLS

- Be able to select the most suitable scientific method to solve the problem from the range of different methods which can be used for the analysis, modelling and simulation of process and combustion systems
- Be able to manage the problem based work and development process within the project theme and to communicate scientific results in a professional manner
- Be able to independently define and analyse scientific problems within the topic of process and combustion, to propose and develop solutions for the present problem and to evaluate these solutions
- Be able to independently continue own development in competence and specialisation
- Be able to follow more sophisticated literature, or state-of-the-art, on CFD, turbulent flow and multiphase flow

COMPETENCES

- Be able to select the most suitable scientific method to solve the problem from the range of different methods which can be used for the analysis, modelling and simulation of process and combustion systems
- Be able to manage the problem based work and development process within the project theme and to communicate scientific results in a professional manner
- Be able to independently define and analyse scientific problems within the topic of process and combustion, to propose and develop solutions for the present problem and to evaluate these solutions
- Be able to independently continue own development in competence and specialisation
- Be able to follow more sophisticated literature, or state-of-the-art, on CFD, turbulent flow and multiphase flow

TYPE OF INSTRUCTION

Problem based project oriented project work in groups. The project work must be documented by a scientific paper (max. 8 pages). If judged necessary, this paper may be accompanied by a project summary report. The project summary report should elaborate the project details and conclusions. The maximum length of the summary report (report without appendices) is 50 pages, and in addition the summary report should follow the rules as laid down by the Study Board of Energy in "Procedure for Project Work", i.e. the total number of pages must not exceed $30 + 15 \times \text{number of students in the project group}$. The project should be based on a combustion or process system, or parts thereof, which involve the use of advanced analysis, simulation or experimental methods. The project should encompass a state-of-the-art analysis of the present system or process and be focused towards finding new insight into the topic. The project can be fully based on experimental work, fully on simulation models or both. The project should be based on an on-going research project at the department or at a commercial cooperation partner. Due to special technical or scientific documentation requirements, the student documents the project work in a project report, which can be prepared individually or in a group within the project theme; however the student's special preferences for the semester must be approved by the Study Board in advance.

EXTENT AND EXPECTED WORKLOAD

Since it is a 20 ECTS project module, the work load is expected to be 600 hours for the student

EXAM

PREREQUISITE FOR ENROLLMENT FOR THE EXAM

- It is a pre-condition that the student has submitted a scientific article and presented the scientific article at the CES conference prior to the project examination. All group members must be present at the conference.

EXAMS

Name of exam	Advanced Combustion and Process Systems
Type of exam	Oral exam based on a project The project group should orally present the project work and scientific paper. The project group members will undergo an individual oral examination with internal adjudicator, based on the scientific paper and the project summary report.
ECTS	20
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Project on 3rd Semester Process Engineering and Combustion Technology (PECT).

The student may follow a relevant study as a guest student (30 ECTS) at another university in Denmark or abroad, see details in Moodle. However, the student's special preferences for the semester must be approved by the Study Board in advance.

FACTS ABOUT THE MODULE

Danish title	Avancerede forbrændings- og processystemer
Module code	N-SEE-K3-1
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	20
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Matthias Mandø

ORGANISATION

Study Board	Study Board of Energy
-------------	-----------------------

Curriculum for the Master of Science (MSc) Programme in Sustainable Energy Engineering 2017

Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

MASTER'S THESIS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 3rd semester on the Master of Science in Sustainable Energy Engineering with specialisation in Process Engineering and Combustion Technology or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension within the area of process engineering and combustion technology at the highest international level
- Be able to critically judge knowledge and identify new scientific problems within the area of process engineering and combustion technology
- Have comprehension of the implications within the research work (research ethics)

SKILLS

- Be able to judge the usefulness of different scientific methods and tools for analysis and problem solving within the field of process engineering and combustion technology
- Be able to use advanced laboratory set-ups, data analysis methods and analysis and modelling methods within the field of process engineering and combustion technology
- Be able to communicate scientific problems both to specialists and the public
- Have obtained skills related to the industrial area within process engineering and combustion technology

COMPETENCES

- Be able to control complex or unexpected working and development situations within process engineering and combustion technology, and be able to develop new solutions
- Independently be able to define and analyse scientific problems, and based on that, make and state the reasons for decisions made
- Independently be able to continue own development in competence and specialisation
- Independently be able to be the head of professional and interdisciplinary development work and be able to undertake the professional responsibility

TYPE OF INSTRUCTION

Problem based project oriented project work. The final project may study new subjects or be an extension of the project work from previous semesters. The subject matter will remain in the area of process engineering and combustion technology. The project may be of theoretical or experimental nature, and will often be in collaboration with an industrial company or other research institution performing research in the area of process engineering and combustion technology.

EXTENT AND EXPECTED WORKLOAD

Since it is a 30 ECTS project module, the work load is expected to be 900 hours for the student

EXAM**EXAMS**

Name of exam	Master's Thesis
Type of exam	Oral exam based on a project
ECTS	30
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Kandidatspeciale
Module code	N-SEE-K4-1
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	30
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Matthias Mandø
Time allocation for external examiners	D

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

MASTER'S THESIS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying all previous semesters on the Master of Science in Sustainable Energy Engineering with specialisation in Process Engineering and Combustion Technology or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension within the area of process engineering and combustion technology at the highest international level
- Be able to critically judge knowledge and identify new scientific problems within the area of process engineering and combustion technology
- Have comprehension of the implications within the research work (research ethics)

SKILLS

- Be able to judge the usefulness of different scientific methods and tools for analysis and problem solving within the field of process engineering and combustion technology
- Be able to use advanced laboratory set-ups, data analysis methods and analysis and modelling methods within the field of process engineering and combustion technology
- Be able to communicate scientific problems both to specialists and the public
- Have obtained skills related to the industrial area within process engineering and combustion technology

COMPETENCES

- Be able to control complex or unexpected working and development situations within process engineering and combustion technology, and be able to develop new solutions
- Independently be able to define and analyse scientific problems, and based on that, make and state the reasons for decisions made
- Independently be able to continue own development in competence and specialisation
- Independently be able to be the head of professional and interdisciplinary development work and be able to undertake the professional responsibility

TYPE OF INSTRUCTION

Problem based project oriented project work. The final project may study new subjects or be an extension of the project work from previous semesters. The subject matter will remain in the area of process engineering and combustion technology. The project may be of theoretical or experimental nature, and will often be in collaboration with an industrial company or other research institution performing research in the area of process engineering and combustion technology.

EXTENT AND EXPECTED WORKLOAD

Since it is a 50 ECTS project module, the work load is expected to be 1500 hours for the student

EXAM

EXAMS

Name of exam	Master's Thesis
Type of exam	Oral exam based on a project
ECTS	50
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

The Master's Thesis is conducted as a long Master's Thesis using both the 3rd and 4th semesters. The long Master's Thesis must include experimental work and must be approved by the Study Board in advance. The amount of experimental work must reflect the allotted ECTS.

FACTS ABOUT THE MODULE

Danish title	Kandidatspeciale
Module code	N-SEE-K4-1LG
Module type	Project
Duration	2 semesters
Semester	Autumn
ECTS	50
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Matthias Mandø
Time allocation for external examiners	D

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

ADVANCED ANALYSIS OF THERMAL MACHINES

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering with a thermal specialisation, Master of Science in Sustainable Energy Engineering with specialisation in Process Engineering and Combustion Technology or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Conversion between different forms of energy
- Design of thermal machines
- Performance characteristics of thermal machines
- Behaviour of in- and outflow conditions for thermal machines
- Advanced analytical, numerical and/or experimental analysis of thermal machines
- Energy, momentum and heat exchange in thermal machines
- Phase change and multi-phase characteristics of thermal machines

SKILLS

- Be able to select and apply appropriate methods for performance analysis of thermal machines
- Be able to apply multi physics modelling in the analysis of thermal machines and components
- Be able to select and apply appropriate equipment for monitoring and performance measurements on thermal machines

COMPETENCES

- Independently be able to simulate thermal machines in design and off-design operation
- Independently be able to evaluate the performance of thermal machines in a given application or system
- Independently be able to evaluate the effect of design changes in thermal machines
- Independently be able to continue the development of own competences in the field of thermal machines

TYPE OF INSTRUCTION

The course is taught by a mixture of lectures, lab exercises, and self-studies.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Advanced Analysis of Thermal Machines
Type of exam	Written and oral exam Oral examination based on a handed-in mini-project/test report (individual or in groups).
ECTS	5

Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Avanceret analyse af termiske maskiner
Module code	N-EE-K3-8
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Henrik Sørensen

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

ADVANCED MODELLING AND CONTROL OF VOLTAGE SOURCE CONVERTERS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering with an electrical specialisation or Master of Science in Sustainable Energy Engineering with specialisation in Offshore Energy Systems or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about average and small-signal models for voltage Source Converter (VSC) circuits including pulse-width modulators and different output filters
- Understand impedance-based approach to get an insightful yet easy-to-implement way for controller design and stability assessment of VSCs
- Understand impedance-based stability analysis of grid synchronisation and outer DC link voltage control loops
- Understand equivalence and differences between models represented by single-input single-output complex transfer functions and multi-input multi-output transfer matrices
- Have knowledge about passivity-based stability analysis and control for robustly stable VSCs with different grid conditions
- Have knowledge about virtual-impedance-based control for active stabilisation and harmonic compensation of VSCs

SKILLS

- Be able to develop small-signal models for the closed-loop-controlled VSC with closed correlations with time-domain simulations
- Be able to design current controller, phase-locked loop, and DC link voltage controllers under given dynamic specifications
- Be able to identify the causes of the different instability phenomena of grid-connected VSCs
- Be able to design and implement different active damping controllers for stabilizing VSCs

COMPETENCES

- Be able to deal with the instability problems in the emerging VSCs-based power systems, which are nowadays commonly found in renewable power plants, electric transportation systems, and flexible ac/dc transmission/distribution systems

TYPE OF INSTRUCTION

The course is taught by a mixture of lectures, workshops, exercises in simulations (PLECS) and experiments (dSPACE 1007). Guest lectures relevant to the course will also be involved.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Advanced Modelling and Control of Voltage Source Converters
Type of exam	Written and oral exam Students should do a mini project and submit the report in groups, and then an oral examination will be held.
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Avancerede modellering of regulering af effektelektroniske konvertere
Module code	N-EE-K3-9
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Xiongfei Wang

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

ANALYSIS OF ADVANCED THERMAL PROCESS SYSTEMS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering with a thermal specialisation or Master of Science in Sustainable Energy Engineering with a specialisation in Process Engineering and Combustion Technology or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have comprehension of the aspects of integration and analysis of advanced thermal processes regarding, for example:
 - Analysis and optimisation of thermal systems using techniques such as pinch analysis and heat exchanger network synthesis using mathematical programming techniques
 - Case: Modelling of part-load conditions in thermal systems including practical control aspects
 - Case: Modelling and integration of advanced fuel cell systems
- Have knowledge about advanced fluid dynamical topics and system analysis of such systems related, for example:
 - Techniques involved in the design of heat/mass exchangers – shell-and-tube, plate, extended surface, evaporators, condensers, humidifiers, etc. Flow induced vibrations
 - Two-phase fluid flow, models, boiling, condensation and instabilities
 - Equations of State. Thermodynamic functions/properties. Maxwell's relations. Residual properties. Phase equilibrium and phase change
 - Heat transfer by radiation. Modelling methods (e.g. Discrete Ordinate, Discrete Transfer, Monte-Carlo, etc). Gaseous radiative properties. CFD modelling of radiative heat transfer

SKILLS

- Be able to identify the elements related to the control aspects of thermal systems
- Be able to apply the knowledge gained to set up experiments on advanced fluid dynamical systems
- Be able to apply the knowledge on advanced fluid dynamical systems related to the above topics

COMPETENCES

- Independently be able to define and analyse scientific problems within the area of advanced thermal process systems and advanced fluid dynamical systems
- Independently be able to be a part of professional and interdisciplinary development work within the area of thermal process systems and advanced fluid dynamical systems

TYPE OF INSTRUCTION

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

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM**EXAMS**

Name of exam	Analysis of Advanced Thermal Process Systems
Type of exam	Oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Analyse af avancerede termiske processer
Module code	N-EE-K3-10
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Thomas Joseph Condra

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

BATTERY ENERGY STORAGE SYSTEMS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering with an electrical or thermal specialisation or Master of Science in Sustainable Energy Engineering with specialisation in Offshore Energy Systems or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about different battery energy storage technologies (e.g. lithium-ion, lead acid etc.) and understand their operation principles
- Understand the operation/role of energy storage devices and their suitability for different applications (e.g., grid services, electrical vehicles etc.)
- Have good knowledge about the performance (static and dynamic) behaviour of batteries and its dependence on the operating conditions (temperature, load current etc.). Gain experience about different performance and thermal modelling approaches and model parameterization techniques.
- Understand the degradation process of lithium-ion and lead-acid batteries from a macroscopic perspective. Gain knowledge about different methods for lifetime estimation of batteries.
- Gain practical knowledge about testing of lead-acid and lithium-ion batteries in laboratory

SKILLS

- Be able to evaluate the suitability of different energy storage technologies for various applications
- Be able to test different battery technologies in laboratory and to measure their most important electrical and thermal parameters
- Be able to derive various battery parameters from laboratory measurements

COMPETENCES

- Be able to develop performance models for different battery technologies based on various requirements
- Independently be able to develop procedures for laboratory testing of batteries

TYPE OF INSTRUCTION

The course will be planned and organised in close interaction with on-going research and development activities at the Department of Energy Technology and its collaborators. All modules include exercises focusing on the presented material; some exercises will be performed using MATLAB and Simulink. Moreover, some exercises will be carried out on programmable battery test stations.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Battery Energy Storage Systems
--------------	--------------------------------

Type of exam	Written and oral exam Each student should submit all the laboratory exercises in the form of a report. The oral examination will be based on the submitted report.
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Energilagringssystemer til batteri
Module code	N-EE-K3-11
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Daniel-Ioan Stroe

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

BIOMASS CONVERSION AND BIOFUELS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering with a thermal specialisation or Master of Science in Sustainable Energy Engineering with specialisation in Process Engineering and Combustion Technology or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Biomass resource quantification
- Thermo-chemical and bio-chemical conversion pathways
- Biorefinery concepts

SKILLS

- Be able to assess suitable conversion routes for specific biomasses
- Be able to carry out chemical analysis of fuels to assess their properties
- Be able to analyse and evaluate processes of biomass conversion to fuel or energy
- Be able to evaluate the sustainability of biofuels from different biomass resources using a life cycle perspective with focus on greenhouse gas emissions
- Be able to apply process modelling methods to biorefinery concepts

COMPETENCES

- Independently be able to assess biomass resources dedicated for bioenergy production and to design systems of biomass conversion, i.e. biorefineries
- Independently be able to design and analyse production processes for converting biomass resource into biofuel

TYPE OF INSTRUCTION

The course is taught by a mixture of lectures, lab. exercises and self-studies.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Biomass Conversion and Biofuels
Type of exam	Written and oral exam Oral examination based on a delivered mini-project/test report (individual or made in groups with max. 2 persons).
ECTS	5
Assessment	7-point grading scale

Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Avancerede biobrændstoffer
Module code	N-EE-K3-12
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Saqib Sohail Toor

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

BIOMASS GASIFICATION, COMBUSTION AND THEIR ADVANCED MODELLING

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module adds to the knowledge obtained in Heat transfer; Fundamentals of CFD; Combustion theory; Fluid mechanics.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Understand solid biomass feedstock: Fuel characterisation, thermochemical conversion and the various sub-processes, heat and mass transfer in biomass thermochemical conversion
- Understand radiation heat transfer without participating medium: Fundamentals, view factors, surface resistance and space resistance, network method
- Understand radiation heat transfer with participating medium: Radiative properties of gas mixture, radiative transfer equation, modelling of radiative heat transfer
- Have knowledge about biomass gasification and combustion on particle scale: Time scale analysis, ignition mechanisms, reactions of gasification, regimes of char reactions, modelling of biomass particle conversion
- Have knowledge about biomass gasification on reactor scale: Principles, key factors, types of gasifiers and their key characteristics, gasifier design, success stories of biomass gasification
- Have knowledge about suspension-firing of biomass: NO_x control by combustion, different arrangements of suspension-firing, modelling of suspension-firing – overview and specific issues, case studies
- Have knowledge about grate-firing of biomass: Key components in grate boilers, breakthrough, potential problems and solutions, modelling of grate-firing – general strategy and examples

SKILLS

- Be able to identify the appropriate utilisation technology for a given biomass based on its properties
- Understand thermal radiation heat transfer, various applications, and advanced modelling of radiation heat transfer without and with participating medium
- Understand the mechanisms and the key issues in biomass gasification and the modelling
- Understand the key sub-processes in biomass combustion and various key biomass combustion technologies (their advantages and disadvantages, and modelling strategies)
- Be able to developing key sub-models for biomass conversion and implementing them into commercial CFD

COMPETENCES

- Have in-depth understanding of all the important issues in biomass gasification and combustion, including combustion physics (e.g., radiative heat transfer, turbulent flow) and combustion chemistry (e.g., pyrolysis, homogeneous and heterogeneous reactions)
- Be able to develop sub-models and codes for the key, special processes in biomass gasification and combustion process and ability to perform a reliable CFD of biomass gasifier and combustor

TYPE OF INSTRUCTION

Lectures in combination with tutorials, assignments and hands-on.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM**EXAMS**

Name of exam	Biomass Gasification, Combustion and their Advanced Modelling
Type of exam	Oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Forgasning af biogas, forbrænding og avanceret modellering
Module code	N-EE-K3-13
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Chungen Yin

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

CONTROL OF GRID CONNECTED PHOTOVOLTAIC AND WIND TURBINE SYSTEMS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering with an electrical specialisation or Master of Science in Sustainable Energy Engineering with specialisation in Offshore Energy Systems or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Understand the operation principle of most common PV and WT systems
- Have knowledge about the most important single- and three-phase inverter topologies, used in renewable energy systems
- Have knowledge about the various pulse width modulation (PWM) techniques used with different inverter topologies
- Understand maximum power point trackers
- Have knowledge about different phase-lock loop (PLL) and control methods, current, voltage and power loops used in control schemes of grid connected inverters
- Have knowledge about grid requirements, standards describing anti-islanding methods, THD limits, etc. that grid connected inverters must comply with

SKILLS

- Be able to implement different PWM strategies for single- and three-phase converters
- Be able to verify different PLL methods based on laboratory experiments
- Be able to design/tune a control scheme for a grid connected converter

COMPETENCES

- Be able to create mathematical models for PV cells, panels and arrays
- Be able to develop simulation models for different PV and WT converter
- Be able to implement a grid connected converter control
- Understand the purpose and methods for grid support by renewable systems

TYPE OF INSTRUCTION

The course will be planned and organised in close interaction with on-going research and development activities at the Department of Energy Technology and its collaborators. Project topics are accounted for when determining the course content. Guest lecturers will also be involved if this is relevant to the course aims. All lectures include exercises focusing on the presented material. Some of the exercises will be done using MATLAB and Simulink. Several exercises will be performed in the PV-lab using experimental set-ups, like current control for a grid connected converter using dSPACE 1103. This way the participants will get a hands-on experience will real-life systems.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM**EXAMS**

Name of exam	Control of Grid Connected Photovoltaic and Wind Turbine Systems
Type of exam	Written and oral exam Each student should submit all the laboratory exercises in the form of a report. The oral examination will be based on the submitted report and the presented material.
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Regulering af nettilsluttede solcelle-og vindmøllesystemer
Module code	N-EE-K3-14
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Tamas Kerekes

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

ELECTROCHEMICAL MODELLING OF FUEL CELLS, ELECTROLYSERS AND BATTERIES

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering, Sustainable Energy Engineering or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about the components that make up an electrochemical cell
- Understand the thermodynamics of fuel cells, electrolyzers and batteries
- Understand the relations governing the kinetics of electrochemical reactions
- Understand the mechanisms governing charge, mass and energy transport within electrodes and electrolytes
- Have knowledge about how to model catalyst poisoning
- Understand how the individual processes are coupled

SKILLS

- Be able to develop models for different types of electrodes
- Be able to combine electrode models with other sub models to create a full electrochemical cell model
- Be able to apply appropriate simplifications depending on the application

COMPETENCES

- Independently be able to analyse and model real electrochemical cells
- Independently be able to identify the validity or limitations of an electrochemical model
- Independently be able to simplify an electrochemical model so it is applicable in modelling of thermal or electrical systems

TYPE OF INSTRUCTION

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

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Electrochemical Modelling of Fuel Cells, Electrolyzers and Batteries
Type of exam	Oral exam
ECTS	5
Assessment	7-point grading scale

Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Elektrokemisk modellering af brændsels-celler, batterier og elektrolyse
Module code	N-EE-K3-15
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Anders Christian Olesen

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

ENERGY CONVERSION AND STORAGE IN FUTURE ENERGY SYSTEMS

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge about the basic principles of electrochemical energy conversion
- Have knowledge about the different types of electrolysers, fuel cells and battery energy storage technologies
- Understand the operation/role of energy storage devices and their suitability for different applications (e.g., grid services, V2G, renewables' grid integration etc.)
- Have good knowledge about the performance (static and dynamic) behaviour of fuel cells, electrolysers and batteries and their dependence on the operating conditions (temperature, load current, etc.). Gain experience about different performance and thermal modelling approaches and model parameterization techniques
- Gain knowledge about the testing of fuel cells, electrolysers and batteries in the laboratory

SKILLS

- Be able to develop a simple model of an electrochemical cell or system
- Be able to test an electrolyser or fuel cell or battery
- Be able to evaluate the suitability of different energy storage technologies for various applications
- Be able to derive various parameters from laboratory measurements

COMPETENCES

- Be able to develop performance models for different battery technologies based on various requirements
- Independently be able to identify the validity or limitations of an electrochemical model
- Be able to analyse data from the fuel cell, electrolyser and battery tests

TYPE OF INSTRUCTION

The course will be planned and organised in close interaction with on-going research and development activities at the Department of Energy Technology and its collaborators. All lectures include exercises focusing on the presented material; some exercises will be performed using MATLAB and Simulink. Moreover, some exercises will be carried out on programmable battery test stations.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Energy Conversion and Storage in Future Energy Systems
Type of exam	Written and oral exam Oral examination based on a delivered mini-project/test report (individual or made in groups).
ECTS	5
Assessment	7-point grading scale

Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Konvertering og lagring af fremtidige energisystemer
Module code	N-EE-K3-16
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Daniel-Ioan Stroe

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

FAULT TOLERANT CONTROL

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying courses on Non-linear control theory and multi-variable control.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have comprehension of the fundamental concepts, terms and methods used within fault tolerant control
- Have comprehension of failure mode and effect analysis (FMEA)
- Have comprehension of modelling faults in dynamic systems and closed loop control systems
- Have comprehension of analytical redundancy
- Have knowledge about statistical fault detection including cumulative sum and generalised likelihood tests
- Have comprehension of residual generation for detection and isolation and decision ruling
- Have comprehension of fault detection using both observers and parity methods

SKILLS

- Be able to use analyse fault development and mitigation approaches
- Be able to list considered faults, how they propagate through the system and assess their severity and occurrence likelihood
- Be able to design fault detection observers
- Be able to design fault detection with parity equations
- Be able to design a FDI observer for unknown inputs
- Be able to develop fault tolerant strategies for ensuring the continuation of the system in the presence of faults
- Be able to design both passive and active fault tolerant controller for continuous systems

COMPETENCES

- Be able to account for the considerations involved in the process of formulating and solving fault tolerant control problems, choosing suited approaches and implementing it in practice
- Be able to develop fault detection and isolation (FDI) algorithms

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. 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
- project work
- workshops
- exercises (individually and in groups)
- teacher feedback
- reflection
- portfolio work
- study circle
- self-study

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM**EXAMS**

Name of exam	Fault Tolerant Control
Type of exam	Written exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Fejltolerant regulering
Module code	N-EE-K3-17
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Henrik Clemmensen Pedersen

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

FUTURE POWER SYSTEM IN DENMARK

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering with an electrical specialisation or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and understanding within the technique of the grid and system challenges that the electricity power system in Denmark is expected to face in the future in terms of design and system operation.

SKILLS

- Be able to explain the grid technique and systemic challenges of electricity supply in Denmark in the future facing, both design and / or terms of system operation
- Be able to analyse and assess the structure, composition, interaction and mutual influence between the relevant parts of the electricity grid and power system in one or more of the fields distribution, transmission, production and consumption
- Be able to use and through that become familiar with earlier learned electrical power system theory
- Be able to identify, evaluate, and argue for changes in existing power system facilities taking into consideration high personal security, high continuity of supply and finance

COMPETENCES

- Be able to explain the grid technique and systemic challenges of electricity supply in Denmark in the future facing, both design and / or terms of system operation
- Be able to analyse and assess the structure, composition, interaction and mutual influence between the relevant parts of the electricity grid and power system in one or more of the fields distribution, transmission, production and consumption
- Be able to use and through that become familiar with earlier learned electrical power system theory
- Be able to identify, evaluate, and argue for changes in existing power system facilities taking into consideration high personal security, high continuity of supply and finance

TYPE OF INSTRUCTION

The course will include lectures; guest-lectures; team work; web-conferences/question time; and conference. With starting point in Denmark's existing electrical power system, and known political objectives and decisions for Denmark (at regional or national level), students must analyse their way through to a concrete solution for the future electricity supply in Denmark, based on the course's theme and within a more defined, self-elected project focus.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM**EXAMS**

Name of exam	Future Power System in Denmark
Type of exam	Written and oral exam Oral examination based on a delivered mini-project/test report (individual or made in groups).
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Fremtidens el-forsyning i Danmark
Module code	N-EE-K3-18
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Florin Iov , Jayakrishnan Radhakrishna Pillai

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

MODERN ELECTRICAL DRIVES

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering with an electrical specialisation or Master of Science in Sustainable Energy Engineering with specialisation in Offshore Energy Systems or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have a solid knowledge about the electromagnetic field behaviour for various types of electrical machines. This gives a firm base for understanding of the advantages and disadvantages of different types of electrical machines. It consequently leads to a good understanding of new types of machines invented in recent years, e.g. the modern drive unit in electric vehicles or wind turbines, and magnetic gears.
- Have a detailed knowledge of the small DC link drive system and the corresponding active damping control methods. This has become a hot topic in recent years.
- Gain good experience about design of various controllers to meet different requirements, e.g. very low speed stable operation, low-cost controller design, drive stability issues, etc.

SKILLS

- Be able to understand and evaluate new types of high performance electrical machines that may occur in the future
- Be able to identify the pros and cons of existing sensorless control methods and design the most proper controller for selected applications
- Be aware of important practical implementation issues when designing the controller
- Be able to test, measure and characterize the performance of different electrical drive systems

COMPETENCES

- Independently be able to contribute to a professional team dealing with design of modern electrical drives, including new high performance electrical machines and advanced control technologies

TYPE OF INSTRUCTION

The course is taught by a mixture of lectures, workshops, exercises, mini-projects and self-studies. Instead of using complicated mathematical equations and electromagnetic theory, particularly-made Finite Element Models visualizing the electromagnetic field behaviour inside a machine will be used to give an easy but deep access to many difficult topics involved in the electrical machine theory. Various advanced sensorless control technologies developed in recent years will be discussed for permanent magnet machine and synchronous reluctance machine (which has received great interests in recent years). Achievements obtained from recent PhD projects carried out at the department will be presented.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM**EXAMS**

Name of exam	Modern Electrical Drives
Type of exam	Written and oral exam Oral examination based on a delivered mini-project/test report (individual or made in groups).
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Moderne elektriske drivsystemer
Module code	N-EE-K3-19
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Kaiyuan Lu

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

MODERN POWER ELECTRONIC DEVICES AND THEIR MODELS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering with an electrical specialisation or Master of Science in Sustainable Energy Engineering with specialisation in Offshore Energy Systems or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have a basic knowledge about figure of merit of present and future wide-bandgap semiconductor materials (SiC, GaN, GaO, diamond, etc.)
- Have a solid knowledge about operating principles and founding equations of modern power electronic devices: SCRs, MOSFETs, IGBTs, rectifiers, FR diodes, Schottky diodes, HEMTs, etc.
- Have a solid knowledge about operating range basing on real-life application, like LVDO, POL, power supplies, welding machines, solar inverters, wind turbines, HVDC, etc.
- Have a basic knowledge about power electronic device design principles, constraints and trade-offs
- Have a good understanding of simulation tools, both at device level and circuit level (PSpice, LTSpice, etc.)
- Understanding of the interaction between the external circuit, including driving circuit, and the power electronic device
- Have a good knowledge about abnormal conditions and instabilities
- Have a hands-on experience on real problems related to power electronic devices, as driver selection, heatsink thermal design, losses and efficiency estimation and measurement

SKILLS

- Be able to recognise and classify traditional and modern power semiconductor devices
- Be able to test and characterize real power devices, both statically and dynamically
- Be able to simulate with good accuracy electrical behaviour of power electronic devices, including power losses and junction temperature estimation
- Be able to select an appropriate power devices for a given real application, e.g. DC/DC or DC/AC converters
- Experience gained from practical tasks will let you be aware of important implementation issues when designing power electronic circuits, e.g. thermal design, safe operating area, etc.

COMPETENCES

- Be able to contribute to a professional team in design of power electronic circuits with skills on part number selection, driving design and simulation of traditional and modern power electronic components

TYPE OF INSTRUCTION

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

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM**EXAMS**

Name of exam	Modern Power Electronic Devices and their Models
Type of exam	Written and oral exam Oral examination based on a delivered mini-project/test report (individual or made in groups).
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Moderne effektelektronikkomponenter og deres modeller
Module code	N-EE-K3-20
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Francesco Iannuzzo

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

NON-LINEAR CONTROL AND MULTI-BODY SYSTEMS

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

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

COMPETENCES

- 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 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 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.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Non-linear Control and Multi-body Systems
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination

Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/
------------------------	--

ADDITIONAL INFORMATION

This course is taught to the 1st semester MSc students at the Mechatronic Control Engineering specialisation and is offered as an elective course at the 3rd semester of all other specialisations. Students of the Mechatronic Control Engineering specialisation cannot elect the module again.

FACTS ABOUT THE MODULE

Danish title	Ikke-lineær regulering og flerlegeme systemer
Module code	N-EE-K1-11
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Lasse Schmidt

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

TEST AND VALIDATION

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds upon knowledge obtained in the modules Applied Statistics and Probability Theory or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

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

TYPE OF INSTRUCTION

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

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Test and Validation
Type of exam	Written and oral exam Oral examination based on a submitted written assignment.

ECTS	5
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Test og validering
Module code	N-EE-K3-21
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Erik Appel Jensen , Henrik Sørensen

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

WIND POWER SYSTEM AND RENEWABLE ENERGY GRID INTEGRATION

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is based on knowledge achieved when studying the 2nd semester on the Master of Science in Energy Engineering with an electrical specialisation or Master of Science in Sustainable Energy Engineering with specialisation in Offshore Energy Systems or similar.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge and comprehension within electrical system overview of wind energy conversion systems
- Have knowledge and comprehension within wind power generators
- Have knowledge and comprehension within the power electronics converters in wind power conversion system
- Have knowledge and comprehension within the wind turbine systems
- Have knowledge and comprehension within optimisation theory and its application on offshore wind farms and electrical systems
- Have knowledge and comprehension within operation and control of wind turbines and wind farms
- Have knowledge and comprehension within renewable energy sources in transmission power systems
- Have knowledge and comprehension within renewable energy sources in distribution power systems

SKILLS

- Be able to apply theories to analyse wind turbine systems
- Be able to apply power flow analysis of large renewable energy systems
- Be able to implement optimisation in an offshore wind farm and design its electrical systems
- Be able to simulate the different grid-connected wind turbine systems, including Double Fed Induction Generator (DFIG) based wind turbines and Permanent Magnet Synchronous Generator (PMSG) based wind turbines
- Be able to analyse the impact of renewable energy sources on the power system

COMPETENCES

- Be able to understand the state-of-art knowledge within the area of renewable energy
- Independently be able to define and analyse scientific problems within the area of wind power systems
- Independently be able to communicate results from advanced wind power technology
- Independently be able to be a part of professional and interdisciplinary development work in renewable energy technology

TYPE OF INSTRUCTION

Lectures, exercises, simulations and group discussions.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student.

EXAM**EXAMS**

Name of exam	Wind Power System and Renewable Energy Grid Integration
Type of exam	Written and oral exam Each student should submit an exercise report. The oral examination will be based on the submitted report.
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

FACTS ABOUT THE MODULE

Danish title	Nettilslutning af vindmøller og bæredygtige energiforsyninger
Module code	N-EE-K3-22
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg, Campus Esbjerg
Responsible for the module	Jiakun Fang

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science