AALBORG UNIVERSITET

MASTER OF SCIENCE (MSC) IN ENGINEERING (MATERIALS AND NANOTECHNOLOGY), 2019

MASTER OF SCIENCE (MSC) IN ENGINEERING
AALBORG

MODULES INCLUDED IN THE CURRICULUM

TABLE OF CONTENTS

PROCESSING AND CHARACTERIZATION

2019/2020

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have gained comprehensive knowledge and understanding of processing and/or fabrication of materials and / or nanomaterials.
- Have gained comprehensive knowledge and understanding of characterization of materials and / or nanomaterials.

SKILLS

- Be able to apply theories in order to choose the appropriate processing/fabrication and characterization methods for a given application.
- Be able to specify a material or a material system for a given application.
- Be able to demonstrate understanding of the material microstructure for the specified material.
- Be able to give a critical evaluation of the methods applied for processing and characterizing a material / material system for a given application.
- Be able to use correct terminology.
- Be able to use methods and tools for processing/fabrication and characterization of materials and nanomaterials.

COMPETENCES

- Be able to devise experiments for documentation.
- Be able to set up a realistic hypothesis for the outcome of a process, obtaining a property, or the like.
- Be able to devise an experimental method to validate a given hypothesis.
- Be able to use advanced experimental or theoretical methods for processing and characterization.
- Be able to apply the background theory and the insight obtained, for validation of the material choice for a given application.
- Be able to apply the background theory in order to design and maybe also fabricate or process materials for specific applications.

TYPE OF INSTRUCTION

The teaching is organized in accordance with the general form of teaching. Please see the programme cirruculum §17.

EXTENT AND EXPECTED WORKLOAD

Since it is a 15 ECTS project module the expected workload is 450 hours for the student.

EXAM

EXAMS

Name of exam	Processing and characterization
Type of exam	Oral exam based on a project
ECTS	15
Assessment	7-point grading scale
Type of grading	Internal examination

FACTS ABOUT THE MODULE

Danish title	Processering og karakterisering
Module code	M-MN-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
Responsible for the module	Jens Christian Moesgaard Rauhe

ORGANISATION

Study Board	Study Board of Materials and Production
Department	Department of Materials and Production
Faculty	Faculty of Engineering and Science

MATERIALS CHARACTERIZATION

2019/2020

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Attain knowledge about the theory behind different materials characterization techniques
- Attain knowledge about the application areas of different materials characterization techniques

SKILLS

- Be able to use different experimental techniques within the areas of ellipsometry, photoluminescence, vibrational spectroscopy, diffraction methods, thermal analysis and atomic force microscopy

COMPETENCES

- Be able to analyse the results of different materials characterization techniques
- Be able to combine characterization techniques for an overall determination of materials structure and behaviour

TYPE OF INSTRUCTION

The form(s) of teaching will be determined and described in the 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 teaching is organized in accordance with the general form of teaching. Please see the programme currcuilum § 17.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module the expected workload is 150 hours for the student.

EXAM

EXAMS

Name of exam	Materials Characterization
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination

FACTS ABOUT THE MODULE

Danish title	Karakterisering af Materialers Egenskaber
Module code	M-MN-K1-2
Module type	Course

Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Jens Christian Moesgaard Rauhe

ORGANISATION

Study Board	Study Board of Materials and Production
Department	Department of Materials and Production
Faculty	Faculty of Engineering and Science

ADVANCED MATERIALS SCIENCE AND PHYSICAL METALLURGY

2019/2020

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge on crystallography, Bravais lattice, point groups, Milles indices.
- Be able to understand the fundamental chemical, physical and microstructural description of materials.
- Be able to understand relation between processing, microstructure and mechanical properties for metals.
- Be able to understand the thermodynamics and kinetic principles of phase transformations in materials.

SKILLS

- Be able to describe and predict microstructures and microstructural changes at heat treatments, solidifications and mechanical treatments.
- Be able to connect processing parameters to mechanical properties for metals.
- Be able to use concepts of electrochemistry in problems pertaining to corrosion, electro polishing and electro deposition

COMPETENCES

- Be able to understand and apply Physical Chemistry in calculating the thermodynamics of simple reactions in materials or between a material and the environment.
- Be able understand and calculate the kinetics of simple diffusion controlled phase transformations.
- Be able to apply knowledge and theory in developing materials with specific mechanical, physical and chemical properties.

TYPE OF INSTRUCTION

The teaching is organized in accordance with the general form of teaching. Please see the programme currcuilum § 17.

The form(s) of teaching will be determined and described in the 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 course/project theme is performed in either English or Danish dependent of the language skills of the participants.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module the expected workload is 150 hours for the student.

EXAM

EXAMS

Name of exam	Advanced Materials Science and Physical Metallurgy
Type of exam	Written or oral exam

ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination

FACTS ABOUT THE MODULE

Danish title	Avanceret Materialevidenskab og Fysisk Metallurgi
Module code	M-MN-K1-3
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Jens Christian Moesgaard Rauhe

ORGANISATION

Study Board	Study Board of Materials and Production
Department	Department of Materials and Production
Faculty	Faculty of Engineering and Science

SOLID MECHANICS WITH MICROSTRUCTURE

2019/2020

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have gained an understanding of basic mechanical properties of engineering materials and modeling procedures used to quantify these properties, as well as the ways in which these properties characterize material response.

SKILLS

- Be able to understand basic continuum mechanical theories and apply them to simple structural components.
- Be able to substantiate different observable deformation modes by underlying physical mechanisms.
- Be able to document knowledge related to the application of selected analytical/numerical methods for materials characterization.

COMPETENCES

- Have gained an awareness of various responses exhibited by solid engineering materials when subjected to mechanical loadings and an explanation of the physical mechanisms associated with design-limiting behavior of engineering materials.
- Have gained an understanding of predictive analytical and computational frameworks that provide quantitative skills to deal with materials-limiting problems in engineering design.

TYPE OF INSTRUCTION

The teaching is organized in accordance with the general form of teaching. Please see the programme cirruculum §17.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module the expected workload is 150 hours for the student.

EXAM

EXAMS

Name of exam	Solid Mechanics with Microstructure
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination

FACTS ABOUT THE MODULE

Danish title	Materialemekanik
Module code	M-DMS-K1-3
Module type	Course

Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Jan Schjødt-Thomsen

ORGANISATION

Study Board	Study Board of Industry and Global Business Development
Department	Department of Materials and Production
Faculty	Faculty of Engineering and Science

MODELLING AND CHARACTERIZATION WITHIN MATERIALS TECHNOLOGY

2019/2020

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have gained comprehensive understanding of modelling and characterization within materials technology.

SKILLS

- Be able to choose a material or material system for a given application
- Be able to demonstrate understanding of the microstructure of the material or material system and its influence on the desired application.
- Be able to give a critical evaluation of the methods applied for determining and/or modelling the microstructure, chemical composition or mechanical and other properties.
- Be able to compare and validate theoretical, numerical and experimental results.

COMPETENCES

- Be able to devise an experimental method and a numerical model to falsify or validate a given hypothesis.
- Be able to use advanced experimental and numerical techniques within the field of materials technology.
- Be able to apply the background theory and the insight obtained, for validation of the material choice for a given application.

TYPE OF INSTRUCTION

The teaching is organized in accordance with the general form of teaching. Please see the programme cirruculum §17.

EXTENT AND EXPECTED WORKLOAD

Since it is a 15 ECTS project module the expected workload is 450 hours for the student.

EXAM

EXAMS

Name of exam	Modelling and Characterization within Materials Technology
Type of exam	Oral exam based on a project
ECTS	15
Assessment	7-point grading scale
Type of grading	External examination

FACTS ABOUT THE MODULE

Danish title	Modellering og karakterisering indenfor materialeteknologi
Module code	M-MN-K2-2

Module type	Project
Duration	1 semester
Semester	Spring
ECTS	15
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Jens Christian Moesgaard Rauhe

ORGANISATION

Study Board	Study Board of Materials and Production
Department	Department of Materials and Production
Faculty	Faculty of Engineering and Science

COMPUTATIONAL MODELING

2019/2020

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The student must obtain knowledge about common numerical methods for modeling of problems in science and engineering, and be able to use the methods for computational modeling. The latter includes the construction and usage of computer programs in Matlab based on the numerical methods, and the usage of commercial software packages. Students completing the module will obtain knowledge within the following areas.

LEARNING OBJECTIVES

KNOWLEDGE

- Common computational modeling methods including but not limited to: Finite-Difference-Time-Domain (FDTD) method, Finite-Difference-Methods in the frequency domain, The Fourier Modal Method (FMM), The Finite Element Method (FEM), and Greens Function Integral Equation Methods (GFIEM).
- Construction of computer programs in Matlab for computational modeling.
- Commercial software packages for computational modeling.

SKILLS

The student must be able to judge which numerical method from a range of methods is most suitable for a specific computational problem. The student must be able to carry out computational modeling by constructing and using his / her own programs in Matlab, and by using commercial software packages.

COMPETENCES

The student will gain insight into numerical methods for computational modeling, and will gain experience in using the methods. This will serve as a foundation based on which the student will be able to choose and use appropriate numerical methods for specific computational problems, including constructing and using numerical programs in matlab, and using commercial software packages.

TYPE OF INSTRUCTION

Lectures combined with theoretical exercises.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module the expected workload is 150 hours for the student.

EXAM

EXAMS

Name of exam	Computational modeling
Type of exam	Active participation and/or written assignment
ECTS	5
Assessment	Passed/Not Passed
Type of grading	Internal examination

FACTS ABOUT THE MODULE

Danish title	Computational Modeling
Module code	M-MN-K2-3
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Jens Christian Moesgaard Rauhe

ORGANISATION

Study Board	Study Board of Materials and Production
Department	Department of Materials and Production
Faculty	Faculty of Engineering and Science

PHYSICS AND CHEMISTRY OF SURFACES

2019/2020

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is built on knowledge obtained in the area of General and Physical Chemistry.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Aim of the course is to provide knowledge about specific aspects as well as physical and chemical phenomena occurring at surfaces and interfaces.

LEARNING OBJECTIVES

KNOWLEDGE

• Structure of crystalline surfaces as well as the methods and techniques for their preparation and characterisation;
• basic thermodynamics and kinetics of surface processes including phenomena of surface tension and adsorption/desorption;

• major interaction forces near the interfaces including van der Waals and double-layer forces;

• physi- and chemi-sorption at surfaces and catalysis;

• structure of interfaces, wetting theory, hydrophobicity, membranes and growth of thin films;

• reactions at interfaces and electrochemistry.

SKILLS

The student will become skilled in solving problems within the topics listed above and will be able to apply theories and methods of surface physics and chemistry.

COMPETENCES

Competencies that are acquired develop and strengthen the knowledge and understanding of theory and methods in surface science, as well as their applications. Based on the skills acquired in this module the student should be able to reflect on and discuss topics from surface science.

TYPE OF INSTRUCTION

Lectures supported by problem solving classes.

EXTENT AND EXPECTED WORKLOAD

This is a 5 ECTS course module and the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Physics and Chemistry of Surfaces
Type of exam	Oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	http://www.engineering.aau.dk/uddannelse/Studieadministration/

FACTS ABOUT THE MODULE

Danish title	Overfladefysik og -kemi (B)
Module code	F-FYS-K2-5
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Language of instruction	Danish and English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Leonid Gurevich, Vladimir Popok

ORGANISATION

Study Board	Study Board of Mathematics, Physics and Nanotechnology
Department	Department of Mathematical Sciences
Faculty	Faculty of Engineering and Science

POLYMERS AND POLYMER COMPOSITES

2019/2020

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

This module is based on knowledge gained in Materials Characterization and Solid Mechanics with Microstructure.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have gained an understanding of the chemical structure and morphology of polymers and their relations to polymer properties
- Attain knowledge on the interdependency between structure, morphology and thermomechanical treatments
- Attain knowledge about selected polymerization processes
- Have gained an understanding of the different types of polymer composite materials, their manufacturing methods and theories for modelling at fiber-, laminae and laminate scale

SKILLS

- Be able to grasp different polymerization principles.
- Be able to model the kinetics of polymerization
- Be able to apply concepts, theories and methods for analysis and design of composite materials.
- Be able to characterize polymers through rheometric experimental techniques.
- Be able to understand the relation between processing conditions and subsequent material properties of polymer and composite materials.

COMPETENCES

- Be able to undertake development and product design using polymers and composite materials.
- Be able to develop procedures for production and verification of components made from polymer and composite materials.

TYPE OF INSTRUCTION

The teaching is organized in accordance with the general form of teaching. Please see the programme cirruculum §17.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module the expected workload is 150 hours for the student.

EXAM

EXAMS

Name of exam	Polymers and Polymer Composites
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination

FACTS ABOUT THE MODULE

Danish title	Polymerer og polymerkompositter
Module code	M-MN-K2-4
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Jens Christian Moesgaard Rauhe

ORGANISATION

Study Board	Study Board of Materials and Production
Department	Department of Materials and Production
Faculty	Faculty of Engineering and Science

MATERIALS ENGINEERING

2019/2020

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Knowledge of subject-specific theory, methods and tools applied for characterization, design, fabrication, or/and modelling.
- Knowledge on advanced applications within the field of specialization for solving technological problems
- Understand the connection between analytical, numerical and experimental methods.

SKILLS

- Be able to apply analytical, numerical and/or experimental methods for characterization, design and/or fabrication of materials within the field of specialization.
- Be able to apply relevant theory to field specific applications
- Be able to solve advanced engineering tasks within the field of specialization.
- Be able to compare and evaluate assumptions, limitations and uncertainties related to the methods applied in connection to finding solutions of advanced engineering challenges.

COMPETENCES

- Be able to handle development-oriented situations in connection to either studying or working.
- Be able to evaluate and apply subject-specific methods and tools applied for characterization, design, fabrication, or/and modelling.
- Be able to analyse and solve an actual problem within materials engineering through application of systematic research and development processes, including advanced analytical, experimental and/or numerical methods and models.
- Be able to use the correct terminology in oral, written and graphical communication and documentation of challenges and solutions within the field of specialization.

TYPE OF INSTRUCTION

The project work is carried out as an independent work process in which the students themselves organize and coordinate their workload in collaboration with a supervisor.

The project may be carried out individually or in groups.

EXTENT AND EXPECTED WORKLOAD

Since it is a 30 ECTS project module the expected workload is 900 hours for the student.

EXAM

EXAMS

Name of exam	Materials engineering
Type of exam	Oral exam based on a project
ECTS	30
Assessment	7-point grading scale

Type of grading	Internal examination

FACTS ABOUT THE MODULE

Danish title	Materialeudvikling
Module code	M-MN-K3-2
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	30
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Jens Christian Moesgaard Rauhe

ORGANISATION

Study Board	Study Board of Materials and Production
Department	Department of Materials and Production
Faculty	Faculty of Engineering and Science

MATERIALS ENGINEERING

2019/2020

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Knowledge of subject-specific theory, methods and tools applied for characterization, design, fabrication, or/and modelling.
- Knowledge on advanced applications within the field of specialization for solving technological problems
- Understand the connection between analytical, numerical and experimental methods.

SKILLS

- Be able to apply analytical, numerical and/or experimental methods for characterization, design and/or fabrication of materials within the field of specialization.
- Be able to apply relevant theory to field specific applications
- Be able to solve advanced engineering tasks within the field of specialization.
- Be able to compare and evaluate assumptions, limitations and uncertainties related to the methods applied in connection to finding solutions of advanced engineering challenges.

COMPETENCES

- Be able to handle development-oriented situations in connection to either studying or working.
- Be able to evaluate and apply subject-specific methods and tools applied for characterization, design, fabrication, or/and modelling.
- Be able to analyse and solve an actual problem within materials engineering through application of systematic research and development processes, including advanced analytical, experimental and/or numerical methods and models.
- Be able to use the correct terminology in oral, written and graphical communication and documentation of challenges and solutions within the field of specialization.

TYPE OF INSTRUCTION

The project work is carried out as an independent work process in which the students themselves organize and coordinate their workload in collaboration with a supervisor.

The project may be carried out individually or in groups.

EXTENT AND EXPECTED WORKLOAD

Since it is a 25 ECTS project module the expected workload is 750 hours for the student.

EXAM

EXAMS

Name of exam	Materials engineering
Type of exam	Oral exam based on a project
ECTS	25
Assessment	7-point grading scale

Type of grading	Internal examination

FACTS ABOUT THE MODULE

Danish title	Materialeudvikling
Module code	M-MN-K3-1
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	25
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Jens Christian Moesgaard Rauhe

ORGANISATION

Study Board	Study Board of Materials and Production
Department	Department of Materials and Production
Faculty	Faculty of Engineering and Science

PROJECT ORIENTED STUDY IN AN EXTERNAL ORGANISATION

2019/2020

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Knowledge of subject-specific theory, methods and tools applied for characterization, design, fabrication, or/and modelling.
- Knowledge on advanced applications within the field of specialization for solving technological problems
- Understand the connection between analytical, numerical and experimental methods.

SKILLS

- Be able to apply analytical, numerical and/or experimental methods for characterization, design and/or fabrication of materials within the field of specialization.
- Be able to apply relevant theory to field specific applications
- Be able to solve advanced engineering tasks within the field of specialization.
- Be able to compare and evaluate assumptions, limitations and uncertainties related to the methods applied in connection to finding solutions of advanced engineering challenges.

COMPETENCES

- Be able to handle development-oriented situations in connection to either studying or working.
- Be able to evaluate and apply subject-specific methods and tools applied for characterization, design, fabrication, or/and modelling.
- Be able to analyse and solve an actual problem within materials engineering through application of systematic research and development processes, including advanced analytical, experimental and/or numerical methods and models.
- Be able to use the correct terminology in oral, written and graphical communication and documentation of challenges and solutions within the field of specialization.

TYPE OF INSTRUCTION

The project work is carried out as an independent work process in which the students themselves organize and coordinate their workload in collaboration with a supervisor.

When doing a project-oriented stay in a company, the student is included in the company's daily work and carry out independent project work on an industrial problem relevant for the company. Concurrent to the work in the company, the student makes a project report, which is evaluated after the ending of the internship. A project-oriented stay in a company has to be approved by the study board.

The project may be carried out individually or in groups.

EXTENT AND EXPECTED WORKLOAD

Since it is a 30 ECTS project module the expected workload is 900 hours for the student.

EXAM

EXAMS

Name of exam	Project Oriented Study in an External Organisation
Type of exam	Oral exam based on a project
ECTS	30
Assessment	7-point grading scale
Type of grading	Internal examination

FACTS ABOUT THE MODULE

Danish title	Projektorienteret forløb i en virksomhed
Module code	M-MN-K3-3
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	30
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Jens Christian Moesgaard Rauhe

ORGANISATION

Study Board	Study Board of Materials and Production
Department	Department of Materials and Production
Faculty	Faculty of Engineering and Science

PROJECT ORIENTED STUDY IN AN EXTERNAL ORGANISATION

2019/2020

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Knowledge of subject-specific theory, methods and tools applied for characterization, design, fabrication, or/and modelling.
- Knowledge on advanced applications within the field of specialization for solving technological problems
- Understand the connection between analytical, numerical and experimental methods.

SKILLS

- Be able to apply analytical, numerical and/or experimental methods for characterization, design and/or fabrication of materials within the field of specialization.
- Be able to apply relevant theory to field specific applications
- Be able to solve advanced engineering tasks within the field of specialization.
- Be able to compare and evaluate assumptions, limitations and uncertainties related to the methods applied in connection to finding solutions of advanced engineering challenges.

COMPETENCES

- Be able to handle development-oriented situations in connection to either studying or working.
- Be able to evaluate and apply subject-specific methods and tools applied for characterization, design, fabrication, or/and modelling.
- Be able to analyse and solve an actual problem within materials engineering through application of systematic research and development processes, including advanced analytical, experimental and/or numerical methods and models.
- Be able to use the correct terminology in oral, written and graphical communication and documentation of challenges and solutions within the field of specialization.

TYPE OF INSTRUCTION

The project work is carried out as an independent work process in which the students themselves organize and coordinate their workload in collaboration with a supervisor.

The semester is completed as a project-oriented stay in a company where the student is included in the company's daily work and carry out independent project work on an industrial problem relevant for the company. Concurrent to the work in the company, the student makes a project report, which is evaluated after the ending of the internship. A project-oriented stay in a company has to be approved by the study board.

The project may be carried out individually or in groups.

EXTENT AND EXPECTED WORKLOAD

Since it is a 25 ECTS project module the expected workload is 750 hours for the student.

EXAM

EXAMS

Name of exam	Project Oriented Study in an External Organisation
Type of exam	Oral exam based on a project
ECTS	25
Assessment	7-point grading scale
Type of grading	Internal examination

FACTS ABOUT THE MODULE

Danish title	Projektorienteret forløb i en virksomhed
Module code	M-MN-K3-4
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	25
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Jens Christian Moesgaard Rauhe

ORGANISATION

Study Board	Study Board of Materials and Production
Department	Department of Materials and Production
Faculty	Faculty of Engineering and Science

MASTER'S THESIS

2019/2020

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have attained thorough knowledge and understanding of a broad range of theoretical, numerical and experimental techniques within the area of specialization.
- Thorough knowledge of relevant theory, methodology, key elements and their mutual contextual relations within the area of specialization.

SKILLS

- Be able to apply scientific theory and methodology to solve a wide variety of problems within the field of specialization.
- Be able to perform scientific work in relevant topics within the field of specialization.
- Be able to apply a wide range of engineering methods in research and development projects in the field of specialization.
- Be able to participate in or lead projects in design, product development, modelling and characterization within the field of specialization.

COMPETENCES

- Identifying, formulating and analysing actual problems using independent, systematic and critical thinking.
- Relating a problem to the scientific area in question and justify the choices made with regards to the problem definition in a relevant way.
- Independently making and justifying the choice of scientific theoretical and/or experimental methods.
- The ability to independently work on a project and apply critical thinking to evaluate both the chosen theory and methodology, as well as to evaluate the analysis and results.
- Presenting relevant academic and professional aspects of the project work in a clear and systematic way.
- Be able to take part in technical development and research
- Be able to direct the technical management of development projects within the industry.
- Be competent to solve new and complicated technical problems by the use of advanced mathematics, scientific and technological knowledge and skills.

TYPE OF INSTRUCTION

In this module, the Master's Thesis is carried out. The module constitutes independent project work and concludes the programme. Within the approved topic, the Master's Thesis must document that the level for the programme has been attained.

EXTENT AND EXPECTED WORKLOAD

Since it is a 30 ECTS project module the expected workload is 900 hours for the student.

EXAM

EXAMS

Name of exam	Master's Thesis
Type of exam	Master's thesis/final project

ECTS	30
Assessment	7-point grading scale
Type of grading	External examination

FACTS ABOUT THE MODULE

Danish title	Kandidatspeciale
Module code	M-MN-K4-1
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	30
Language of instruction	English
Location of the lecture	Campus Aalborg
Responsible for the module	Jens Christian Moesgaard Rauhe

ORGANISATION

Study Board	Study Board of Materials and Production
Department	Department of Materials and Production
Faculty	Faculty of Engineering and Science

SEMICONDUCTORS: PHYSICS, DEVICES AND ENGINEERING

2019/2020

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module is built on knowledge obtained in Solid State Physics and Basic Quantum Mechanics.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

To provide an understanding of semiconductor properties, principles of operation of important semiconductor components as well as knowledge about methods of synthesis of semiconductor materials and basic technologies towards device fabrication.

LEARNING OBJECTIVES

KNOWLEDGE

• Crystalline structure and specific properties of semiconductors
• Electronic band structure of semiconductors, both intrinsic and doped onces, as well as statistics and dynamics of charge carriers

• Characteristics of basic components including pn junctions, bipolar transistors, metal-oxide-semiconductor components and devices for power electronics

• Basic methods and technologies for fabrication of semiconductor devices

SKILLS

The student should be able:

• to explain and use theory and methods describing properties of semiconductors, including crystal structure, electronic characteristics of intrinsic and doped semiconductors as well as statistics and dynamics of charge carriers
• to explain properties and characteristics of basic semiconductor-based components as well as technologies used for fabrication of semiconductor devices.

COMPETENCES

The student should develop and strengthen the knowledge about properties of semiconductors as well as basic principles and technologies behind the semiconductor-based devices. The student should be able to give reasons and arguments based on the concepts of semiconductor physics and technology.

TYPE OF INSTRUCTION

Lectures with exercises.

EXTENT AND EXPECTED WORKLOAD

This is a 5 ECTS course module and the work load is expected to be 150 hours for the student.

EXAM

EXAMS

Name of exam	Semiconductors: Physics, Devices and Engineering
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	Halvledere: fysik, komponenter og teknologi
Module code	F-FYS-K3-9
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Vladimir Popok

ORGANISATION

Study Board	Study Board of Mathematics, Physics and Nanotechnology
Department	Department of Mathematical Sciences
Faculty	Faculty of Engineering and Science

SYNTHESIS AND MODELLING WITHIN NANOMATERIALS AND NANOPHYSICS

2019/2020

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have gained comprehensive knowledge and understanding of fabrication and modelling used, used in the area of nanomaterials and nanophysics.

SKILLS

- Be able to choose a material or material system for a given application
- Be able to fabricate and/or model a material or materials system for a given application
- Be able to demonstrate understanding of the micro- or nanostructured material or materials system and its influence on the desired application.
- Be able to give a critical evaluation of the methods applied for characterization, fabrication and/or modelling of nanostructured materials.
- Be able to compare theoretical, numerical and experimental results.

COMPETENCES

- Be able to devise an experimental method and a numerical model to falsify or validate a given hypothesis.
- Be able to use advanced experimental and numerical techniques within the field of nanomaterials and nanophysics.
- Be able to apply the background theory and the insight obtained, to synthesize and model materials for a given application.

TYPE OF INSTRUCTION

The teaching is organized in accordance with the general form of teaching. Please see the programme cirruculum §17.

EXTENT AND EXPECTED WORKLOAD

Since it is a 15 ECTS project module the expected workload is 450 hours for the student.

EXAM

EXAMS

Name of exam	Synthesis and Modelling within Nanomaterials and Nanophysics
Type of exam	Oral exam based on a project
ECTS	15
Assessment	7-point grading scale
Type of grading	External examination

FACTS ABOUT THE MODULE

Danish title	Syntese og modellering indenfor nanomaterialer og nanofysik
Module code	M-MN-K2-1
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	15
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Jens Christian Moesgaard Rauhe

ORGANISATION

Study Board	Study Board of Materials and Production
Department	Department of Materials and Production
Faculty	Faculty of Engineering and Science

QUANTUM MATERIALS AND OPTICAL NANOSTRUCTURES

2019/2020

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge in the area of General physics and Electromagnetism.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The student must obtain knowledge about different types of nano- and quantum-scale components, their electronic and optical properties, and how these properties can be obtained by theoretical modeling and by optical and electronic microscopy techniques.

LEARNING OBJECTIVES

KNOWLEDGE

Knowledge within the following areas

- Electronic and optical properties of quantum and nanoscale materials
- Electric conductivity and transport at the quantum scale and quantized conductance
- Electric tunneling microscopy techniques and optical microscopy techniques for nano- and quantum-scale structures
- Optical response of nanomaterials including effects due to electronic quantization
- Different types of optical nanostructures and materials: e.g. plasmonic nanostructures, photonic crystals and metamaterials
- Theoretical modeling of the electronic and optical properties of nanostructures

SKILLS

- The student must be able to apply the knowledge in above mentioned areas for solving problems in said areas, and will be able to apply theories and methods related to quantum materials and optical nanostructures.

COMPETENCES

- Based on given information the student must be able to discuss and argument using concepts from the field of quantum materials and optical nanostructures.

TYPE OF INSTRUCTION

Lectures combined with theoretical exercises.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS project module the expected workload is 150 hours for the student.

EXAM

EXAMS

Name of exam	Quantum materials and optical nanostructures
Type of exam	Written or oral exam

ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination

FACTS ABOUT THE MODULE

Danish title	Kvantematerialer og optiske nanostrukturer
Module code	F-NFM-K2-3
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Jens Christian Moesgaard Rauhe

ORGANISATION

Study Board	Study Board of Materials and Production
Department	Department of Materials and Production
Faculty	Faculty of Engineering and Science

FRACTURE MECHANICS AND FATIGUE

2019/2020

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have gained a comprehensive understanding of fracture mechanics.
- Have gained knowledge in applying classical methods in designing against fatigue fracture by studying notches and their effect, by studying strain-fatigue, and by analysing eigen-stress states.
- Have gained an understanding of how to apply fracture mechanics in the assessment of reliability of practical designs and machine elements.

SKILLS

- Be able to assess the stability of cracks using Griffith's and Irwin's fracture criteria, energy release rate, and toughness concepts
- Be able to apply linear elastic solutions for sharp cracks and obtain the stress intensity factor.
- Be able to assess mixed mode loading and apply crack growth direction hypotheses
- Be able to assess crack growth by fatigue, partial damage and load spectra.
- Be able to assess crack initiation, notches and their effect.
- Be able to determine life time and apply methods for improving the fatigue strength and life time of machine elements and welded details.

COMPETENCES

- Be able to understand and apply linear elastic concepts in assessing the stability of cracked structures under static and fatigue loading.
- Be able to distinguish between different fatigue regimes, i.e. elastic or plastic, and un-cracked or pre-cracked, and apply correct methodology to each case in relevant structures.
- Be able to determine the lifetime of welded components, and explain fatigue in welded components on the basis of fracture mechanical concepts.

TYPE OF INSTRUCTION

The teaching is organized in accordance with the general form of teaching. Please see the programme cirruculum §17.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module the expected workload is 150 hours for the student.

EXAM

EXAMS

Name of exam	Fracture Mechanics and Fatigue
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/digitalAssets/332/332984_faellesbestemmelser_230617.pdf

FACTS ABOUT THE MODULE

Danish title	Brudmekanik og udmattelse
Module code	M-DMS-K1-4
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Jan Schjødt-Thomsen, Jens Henrik Andreasen

ORGANISATION

Study Board	Study Board of Industry and Global Business Development
Department	Department of Materials and Production
Faculty	Faculty of Engineering and Science

TEST AND VALIDATION

2019/2020

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

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

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
Language of instruction	English
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

FINITE ELEMENT METHODS

2019/2020

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

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

SKILLS

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

COMPETENCES

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

TYPE OF INSTRUCTION

The teaching is organized in accordance with the general form of teaching. Please see the programme cirruculum §17.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module the expected workload is 150 hours for the student.

EXAM

EXAMS

Name of exam	Finite Element Methods
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination

FACTS ABOUT THE MODULE

Danish title	Elementmetoder
Module code	M-DMS-K1-5
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Erik Lund

ORGANISATION

Study Board	Study Board of Materials and Production
Department	Department of Materials and Production
Faculty	Faculty of Engineering and Science

FASTSTOFFYSIK II: ELEKTRONISK STRUKTUR

2019/2020

FORUDSÆTNINGER/ANBEFALEDE FORUDSÆTNINGER FOR AT DELTAGE I MODULET

Modulet bygger på viden opnået i modulet Grundlæggende mekanik og Termodynamik, Lineær algebra, Calculus, Faststoffysik I: geometrisk struktur samt Grundlæggende kvantemekanik.

MODULETS INDHOLD, FORLØB OG PÆDAGOGIK

Studerende, der gennemfører modulet, vil opnå en indsigt i elektroniske og magnetiske egenskaber af faste stoffer samt en række fænomener, som opstår i faste stoffer, når en eller flere dimensioner er på nanoskala.

LÆRINGSMÅL

VIDEN

• Skal have viden om grundlæggende begreber og teorier vedrørende den elektroniske struktur af faste stoffer, både metaller og halvledere
• Skal have viden om metoder til beregning af elektronisk båndstruktur og båndgab

• Skal have viden om magnetiske egenskaber af faste stoffer, herunder den mikroskopiske beskrivelse af dia-, para- og ferromagnetisme.

• Skal have viden om udvalgte nanostrukturers elektroniske og magnetiske egenskaber

FÆRDIGHEDER

• Skal kunne redegøre for og anvende grundlæggende begreber og teorier vedrørende, den elektroniske struktur af faste stoffer, både metaller og halvledere
• Skal kunne redegøre for teorier og metoder til beregning af elektronisk båndstruktur i faste stoffer

• Skal kunne redegøre for teorier til beregning af magnetiske egenskaber af faste stoffer

KOMPETENCER

Kompetencerne som opnås, skal udvikle og styrke kendskab til, forståelse af og anvendelse af teorier og metoder i faststoffysik. Den studerende skal ud fra givne forudsætninger kunne ræsonnere og argumentere med begreber fra faststoffysik.

UNDERVISNINGSFORM

Forelæsninger med tilhørende opgaveregning.

OMFANG OG FORVENTET ARBEJDSINDSATS

Kursusmodulets omfang er 5 ECTS svarende til 150 timers studieindsats.

EKSAMEN

PRØVER

Prøvens navn	Faststoffysik II: Elektronisk struktur
Prøveform	Mundtlig
ECTS	5
Bedømmelsesform	7-trins-skala
Censur	Intern prøve
Vurderingskriterier	Som angivet i Fællesbestemmelser for uddannelser (Vurderingskriterier). http://www.engineering.aau.dk/uddannelse/Studieadministration/

FAKTA OM MODULET

Engelsk titel	Solid State Physics II: Electronic Structure
Modulkode	F-FYS-K1-4
Modultype	Kursus
Varighed	1 semester
Semester	Efterår
ECTS	5
Undervisningssprog	Dansk og engelsk
Tomplads	Ja
Undervisningssted	Campus Aalborg
Modulansvarlig	Lars Diekhöner

ORGANISATION

Studienævn	Studienævnet for Matematik, Fysik og Nanoteknologi
Institut	Institut for Matematiske Fag
Fakultet	Det Ingeniør- og Naturvidenskabelige Fakultet