AALBORG UNIVERSITET

MASTER OF SCIENCE IN ENGINEERING (NANOMATERIALS AND NANOPHYSICS), 2017

MASTER OF SCIENCE (MSC) IN ENGINEERING
AALBORG

MODULES INCLUDED IN THE CURRICULUM

TABLE OF CONTENTS

CHARACTERISATION AND SYNTHESIS (PROJECT)

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

As part of the project a workshop within some selected topic of physics will be carried out. It will be obligatory for all students and should be considered as a repetition within these areas. The workshop consists of lectures and has an individual continuous evaluation based on exercises given through the lectures.

Workshop will cover:

Knowledge within the following areas:
Quantum mechanics: The general concepts and methods of quantum mechanics covering subjects like: Operators, wave functions and eigenvalues. The Schrödinger equation. position, momentum, energy and angular momentum in quantum mechanics.

Solid State Physics: Crystal structure, diffraction and reciprocal lattice, vibrations and phonons, electronic band structure.

Optics: Geometrical optics (ray tracing, imaging and aberrations) and physical optics (polarization, interference and diffraction).

Skills in:

Basic quantum mechanics, solid state physics and optics.

Competencies:

The student will be able to use the described theories and methods to understand and solve problems within the described areas of quantum mechanics, solid state physics and optics. Furthermore it will enable them to better follow the courses in the Master Program of nanomaterials and nanophysics.

Project:

This project module will give the student experience with advanced methods for synthesis and characterisation of nanostructures and nanomaterials.

LEARNING OBJECTIVES

KNOWLEDGE

• Methods for creation of nanostructures
• Methods for characterisation of nanostructures

SKILLS

• Optical spectroscopy on nanostructures
• Nanolithography

• Advanced microscopy (e.g. SEM, AFM)

COMPETENCES

• Application of advanced methods for creation of small structures based on lithography and/or self-organising systems
• Application of various techniques for studying the fundamental properties of nanostructures like, e.g., size, shape, and electronic properties

TYPE OF INSTRUCTION

Workshop and project work.

EXTENT AND EXPECTED WORKLOAD

This is a 15 ECTS project module and the work load is expected to be 450 hours for the student.

EXAM

EXAMS

Name of exam	Characterisation and Synthesis (Project)
Type of exam	Oral exam based on a project Since the workshop is an integrated part of the project it is obligatory for all students to participate. A successful participation in the workshop is a precondition for participation in the project examination. The project exam comprises of an oral evaluation based on a project report.
ECTS	15
Permitted aids	All written and all electronic aids
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	Karakterisering og syntese (projekt)
Module code	F-NFM-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	Lars Diekhöner, Thomas Møller Søndergaard

ORGANISATION

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

MATERIALS CHEMISTRY

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module adds to the knowledge obtained in Inorganic Chemistry and Physical Chemistry

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The purposes of the course are to introduce both fundamental chemical principles of materials and nano-materials, and main methods for developing, optimizing, post-treating and characterizing materials regarding different physical and chemical performances.

The focus will be placed on the relation between chemical composition, structure and properties. The course will introduce the current status of materials and nano-materials technologies.

Materials chemistry focuses on the fundamental principles and applications of both conventional and advanced inorganic materials. The course is divided into the following two parts.

1. General inorganic materials chemistry and characterization of inorganic materials (e.g., glass chemistry, ceramic chemistry, metal chemistry, cement industry)
2. Chemistry of organic and inorganic nano-materials (e.g., thin films, nano-crystals and –particles, nanotubes, mesoporous materials, nano wires, etc.).

LEARNING OBJECTIVES

KNOWLEDGE

Students who have passed the module should be able to

- Understand the fundamental principles of materials chemistry and how it relates to practical use
- Explain different application areas of materials and ways to optimize the production process of materials

SKILLS

- Prepare, synthesize and modify materials to reach target properties using theoretical and practical knowledge in materials chemistry
- Design, synthesize, and produce nanostructured materials with given properties.
- Characterize conventional materials and nano-materials

EXTENT AND EXPECTED WORKLOAD

150 hours

EXAM

EXAMS

Name of exam	Materials Chemistry
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

FACTS ABOUT THE MODULE

Danish title	Materialekemi
Module code	K-KEM-K1-20
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	Yuanzheng Yue, Morten Mattrup Smedskjær

ORGANISATION

Study Board	Study Board of Biotechnology, Chemistry and Environmental Engineering
Department	Department of Chemistry and Bioscience
Faculty	Faculty of Engineering and Science

SYNTHESIS AND CHARACTERISATION (COURSE MODULE)

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge in the area of Electronic structures of solids and Nanofabrication.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

• Optical characterisation techniques
• Ellipsometry

• Photo luminescense

• Electron microscopy

• Electron beam writing

• Thin film deposition

• Reactive ion etching

• Fucused ion beam lithography

• Atomic force microscopy

SKILLS

• Apply basic experimental techniques for geometrical characterisation of nanostructures
• Synthesise and characterise thin film

• Produce surface structures using particle beam lithography

COMPETENCES

• Be able to design fabrication processes for nano-scale components
• Be able to produce simple components

• Be able to analyse results and compare to basic limitations

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	Synthesis and Characterisation (course module)
Type of exam	Active participation and/or written assignment Individual continuous evaluation based on exercises given through the course.
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	Syntese og karakterisering (kursusmodul)
Module code	F-FYS-K3-8
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	Danish and English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Christian Buhl Sørensen

ORGANISATION

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

SEMICONDUCTORS: PHYSICS, DEVICES AND ENGINEERING

2018/2019

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

FUNCTIONAL NANOSTRUCTURES

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge obtained from project on NFM1.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

This project module will give the student experience with advanced methods for creation of functional nanostructures. In addition, possible applications of the created nanostructures will be investigated

LEARNING OBJECTIVES

KNOWLEDGE

Students who pass this module develop:
Knowledge on:

• Methods for creation of functional nanostructures

• Applications of functional nanostructures

SKILLS

Students who pass this module develop:
Skills in:

• Characterisation of functional nanostructures

• Theoretical description of the properties of functional nanostructures

COMPETENCES

Students who pass this module develop:
Competencies:

• Through application of micro- and macroscopic modelling the student will be able to describe the properties and functionality of nanostructures.

• Applications of the properties of the designed nanostructures for adding special functions to macroscopic components

TYPE OF INSTRUCTION

Project work.

EXTENT AND EXPECTED WORKLOAD

This is a 15 ECTS project module and the work load is expected to be 450 hours for the student.

EXAM

EXAMS

Name of exam	Functional Nanostructures
Type of exam	Oral exam based on a project
ECTS	15
Permitted aids	All written and all electronic aids
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	Funktionelle nanostrukturer
Module code	F-NFM-K2-1
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	15
Language of instruction	Danish and English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Lars Diekhöner

ORGANISATION

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

OPTICAL NANOSTRUCTURES AND MATERIALS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge in the area of Electromagnetism, and Optics and Spectroscopy.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The student must obtain knowledge about optical nanostructures and components, optical microscopy techniques for nanostructures, propagation, scattering and absorption of light in nanostructures, the optical response of nanomaterials, and the related theory and theoretical methods.

Students completing the module will obtain:

LEARNING OBJECTIVES

KNOWLEDGE

Knowledge within the following areas
• Optical nanostructures and components

• Optical microscopy techniques for nano- and microstructures including the physical limitations to the resolution of the microscopies

• Theoretical methods for the optics of nanostructures including the modeling of electromagnetic fields in nanostructures, the scattering of light by nanostructures, and propagation and absorption of light in nanostructures.

• Optical response of nanomaterials including effects due to electronic quantization in nanoscale structures

SKILLS

The student must be able to apply the knowledge in above mentioned areas for solving problems including modeling of the optics of nanostructures on a computer.

COMPETENCES

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

TYPE OF INSTRUCTION

Lectures combined with theoretical 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	Optical Nanostructures and Materials
Type of exam	Written or oral exam
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	Optiske nanostrukturer og -materialer
Module code	F-NFM-K2-2
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	Thomas Møller Søndergaard

ORGANISATION

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

COMPUTATIONAL MODELING FOR PHYSICS AND ENGINEERING

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on a solid background in either physics or an engineering discipline. The type of computational problems used as examples in the course will be selected according to the background of the participants.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The student must obtain knowledge about common numerical methods for modeling of problems in physics 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:

LEARNING OBJECTIVES

KNOWLEDGE

Knowledge within the following areas
• Common numerical methods in physics 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 numerical modeling of physics and engineering problems.

• 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 problem in physics or engineering. The student must be able to carry out computational modeling for physics and engineering by constructing and using his / her own programs in Matlab based on common numerical methods, and by using commercial software packages.

COMPETENCES

The student will gain insight into numerical methods for computational modeling in physics and engineering, 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 problems in physics and engineering, 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

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	Computational Modeling for Physics and Engineering
Type of exam	Written exam Evaluation of report on a specific computational modeling study carried out during the semester.
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	Numerisk modellering i fysik og ingeniørvidenskab (A)
Module code	F-FYS-K2-4
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	Thomas Møller Søndergaard

ORGANISATION

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

PHYSICS AND CHEMISTRY OF SURFACES

2018/2019

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 Gurevitch, Vladimir Popok

ORGANISATION

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

KANDIDATSPECIALE (30 ECTS)

2018/2019

MODULETS INDHOLD, FORLØB OG PÆDAGOGIK

LÆRINGSMÅL

VIDEN

- Either specialist information on one or a few chosen elements of the relevant topic.
- Or broader insight in the topic with regards to theory, methodology, key elements and their mutual contextual relations.
- Or competencies that, in a relevant way, support and expand the actual competence profile of the student.

FÆRDIGHEDER

- Applying nanotechnology.

KOMPETENCER

- 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 apply critical thinking to evaluate both the chosen theory and methodology, as well as to evaluate the analysis, results and conclusions of the project both during and at the end of the project.
- Presenting relevant academic and professional aspects of the project work in a clear and systematic way.

UNDERVISNINGSFORM

It will be done as problem based project work.

OMFANG OG FORVENTET ARBEJDSINDSATS

Kursusmodulets omfang er 30 ECTS svarende til 900 timers studieindsats.

EKSAMEN

PRØVER

Prøvens navn	Master's Thesis (30 ECTS)
Prøveform	Speciale/afgangsprojekt
ECTS	30
Bedømmelsesform	7-trins-skala
Censur	Ekstern prøve
Vurderingskriterier	Som angivet i Fællesbestemmelser for uddannelser: http://www.engineering.aau.dk/uddannelse/Studieadministration/

FAKTA OM MODULET

Engelsk titel	Master's Thesis (30 ECTS)
Modulkode	F-NFM-K4-1
Modultype	Projekt
Varighed	1 semester
Semester	Forår
ECTS	30
Undervisningssted	Campus Aalborg
Modulansvarlig	Thomas Garm Pedersen
Censornorm	D

ORGANISATION

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

ADVANCED APPLICATIONS OF NANOTECHNOLOGY (30 ECTS)

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge obtained from the project on NFM2.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The project on the 3rd semester can either be a normal semester project of up to 30 ECTS or can be combined with the Master's thesis to a Long Master's Thesis. In case of a separate project, the scope of the project can vary between 15, 20, 25, and 30 ECTS dependent on how many elective courses are chosen by the student. A Long Master's Thesis can also vary between 45, 50, and 60 ECTS dependent on how many elective courses are taken by the student.

If the project is less than 30 ECTS the workload of the project is reduced in accordance to the number of ECTS.

This project module will give the student experience with independently applying nanotechnology within a chosen technological area.

LEARNING OBJECTIVES

KNOWLEDGE

Students who pass this module develop:
Knowledge on:

• Advanced applications of nanotechnology for solving technological problems.

SKILLS

Students who pass this module develop:
Skills in:

• Applied aspects of nanotechnology.

COMPETENCES

Students who pass this module develop:
Competencies:

• Given a problematic technological issue the student can use different tools from nanotechnology to find solutions to the actual problem.

TYPE OF INSTRUCTION

Project work.

EXTENT AND EXPECTED WORKLOAD

This is a 30 ECTS project module and the work load is expected to be 900 hours for the student.

EXAM

EXAMS

Name of exam	Advanced Applications of Nanotechnology (30 ECTS)
Type of exam	Oral exam based on a project
ECTS	30
Permitted aids	All written and all electronic aids
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	Avancerede anvendelser af nanoteknologi (30 ECTS)
Module code	F-NFM-K3-1
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	30
Language of instruction	Danish and English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Thomas Garm Pedersen

ORGANISATION

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

ADVANCED APPLICATIONS OF NANOTECHNOLOGY (25 ECTS)

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge obtained from the project on NFM2.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The project on the 3rd semester can either be a normal semester project of up to 30 ECTS or can be combined with the Master's thesis to a Long Master's Thesis. In case of a separate project, the scope of the project can vary between 15, 20, 25, and 30 ECTS dependent on how many elective courses are chosen by the student. A Long Master's Thesis can also vary between 45, 50, and 60 ECTS dependent on how many elective courses are taken by the student.

If the project is less than 30 ECTS the workload of the project is reduced in accordance to the number of ECTS.

This project module will give the student experience with independently applying nanotechnology within a chosen technological area.

LEARNING OBJECTIVES

KNOWLEDGE

• Advanced applications of nanotechnology for solving technological problems.

SKILLS

• Applied aspects of nanotechnology.

COMPETENCES

• Given a problematic technological issue the student can use different tools from nanotechnology to find solutions to the actual problem.

TYPE OF INSTRUCTION

Project work.

EXTENT AND EXPECTED WORKLOAD

This is a 25 ECTS project module and the work load is expected to be 750 hours for the student.

EXAM

EXAMS

Name of exam	Advanced Applications of Nanotechnology (25 ECTS)
Type of exam	Oral exam based on a project
ECTS	25

Permitted aids	All written and all electronic aids
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	Avancerede anvendelser af nanoteknologi (25 ECTS)
Module code	F-NFM-K3-5
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	25
Language of instruction	Danish and English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Thomas Garm Pedersen

ORGANISATION

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

ADVANCED APPLICATIONS OF NANOTECHNOLOGY (20 ECTS)

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The project on the 3rd semester can either be a normal semester project of up to 30 ECTS or can be combined with the Master's thesis to a Long Master's Thesis. In case of a separate project, the scope of the project can vary between 15, 20, 25, and 30 ECTS dependent on how many elective courses are chosen by the student. A Long Master's Thesis can also vary between 45, 50, and 60 ECTS dependent on how many elective courses are taken by the student.

If the project is less than 30 ECTS the workload of the project is reduced in accordance to the number of ECTS.

This project module will give the student experience with independently applying nanotechnology within a chosen technological area.

LEARNING OBJECTIVES

KNOWLEDGE

• Advanced applications of nanotechnology for solving technological problems.

SKILLS

• Applied aspects of nanotechnology.

COMPETENCES

• Given a problematic technological issue the student can use different tools from nanotechnology to find solutions to the actual problem.

TYPE OF INSTRUCTION

Project work.

EXTENT AND EXPECTED WORKLOAD

This is a 20 ECTS project module and the work load is expected to be 600 hours for the student.

EXAM

EXAMS

Name of exam	Advanced Applications of Nanotechnology (20 ECTS)
Type of exam	Oral exam based on a project
ECTS	20
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	Avancerede anvendelser af nanoteknologi (20 ECTS)
Module code	F-NFM-K3-2
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	20
Language of instruction	Danish and English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Thomas Garm Pedersen

ORGANISATION

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

ADVANCED APPLICATIONS OF NANOTECHNOLOGY (15 ECTS)

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge obtained from the project on NFM2.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The project on the 3rd semester can either be a normal semester project of up to 30 ECTS or can be combined with the Master's thesis to a Long Master's Thesis. In case of a separate project, the scope of the project can vary between 15, 20, 25, and 30 ECTS dependent on how many elective courses are chosen by the student. A Long Master's Thesis can also vary between 45, 50, and 60 ECTS dependent on how many elective courses are taken by the student.

If the project is less than 30 ECTS the workload of the project is reduced in accordance to the number of ECTS.

This project module will give the student experience with independently applying nanotechnology within a chosen technological area.

LEARNING OBJECTIVES

KNOWLEDGE

• Advanced applications of nanotechnology for solving technological problems.

SKILLS

• Applied aspects of nanotechnology.

COMPETENCES

• Given a problematic technological issue the student can use different tools from nanotechnology to find solutions to the actual problem.

TYPE OF INSTRUCTION

Project work.

EXTENT AND EXPECTED WORKLOAD

This is a 15 ECTS project module and the work load is expected to be 450 hours for the student.

EXAM

EXAMS

Name of exam	Advanced Applications of Nanotechnology (15 ECTS)
Type of exam	Oral exam based on a project
ECTS	15

Permitted aids	All written and all electronic aids
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	Avancerede anvendelser af nanoteknologi (15 ECTS)
Module code	F-NFM-K3-4
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	15
Language of instruction	Danish and English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Thomas Garm Pedersen

ORGANISATION

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

ACADEMIC INTERNSHIP (30 ECTS)

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

This module is based on knowledge obtained on the 1st and 2nd semester of the master programme.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

• Discuss the subject matter of the project specified within the area of the study programme

SKILLS

• Solve complex problems using theory and concepts within physics
• Evaluate and choose among potentially relevant theories, concepts and methodologies applied to solve problem within physics.

• Evaluate the relevance and limitations of the theories, concepts, methods and tools actually applied in the project

• Account for any choices made during the problem analysis and solution development

• Develop solution alternatives and evaluate the consequences of solution alternatives and make a well-informed choice based on that

• Plan, execute and report an extensive individual research project within an agreed time frame

• Write a well-structured project report, which meets all the usual requirements of an academic work, including:

o Empirical background

o Research problem/project objective

o Relevant theory

o Research design:

o Presentation of data

o Presentation and discussion of findings

o Evaluation of the project; i.e., findings, methods and, if relevant, considerations regarding the limitations and generalizability of the study.

o specific for internship: a personal reflection is required, a reflection on: how was it to work alone, full-time in a company, and, if applicable, in a different country with a different culture, language, industrial structure, etc.

COMPETENCES

• Analyze and solve an actual problem of industrial relevance through application of systematic research and development processes, including advanced analytical, experimental, and/or numerical methods and models
• Work together with an organization and identify problems and finally develop solutions

• Operationalize theoretical contributions in a practical setting

• Compare and critically evaluate the results of the project in relation to existing knowledge and accepted theories within the subject area

• Communicate a balanced view of the results and conclusions of the project in well-organized written and oral presentation

TYPE OF INSTRUCTION

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.

EXTENT AND EXPECTED WORKLOAD

This is a 30 ECTS project module and the work load is expected to be 900 hours for the student.

EXAM

EXAMS

Name of exam	Academic Internship
Type of exam	Oral exam based on a project
ECTS	30
Permitted aids	All written and all electronic aids
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	Projektorienteret forløb i en virksomhed (30 ECTS)
Module code	F-FYS-K3-4
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	30
Language of instruction	Danish and English

Location of the lecture	Campus Aalborg
Responsible for the module	Lars Diekhöner

ORGANISATION

Study Board	Study Board of Mathematics, Physics and Nanotechnology
Department	Department of Mathematical Sciences
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

REACTION ENGINEERING AND MOLECULAR ELECTRONICS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge in the area of Physical Chemistry, Inorganic and Organic Chemistry, Lab-on-a-Chip, Basic Quantum Mechanics, and Microbiology.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

• Must acquire knowledge about basic design principles and modeling of chemical, biochemical, and biotechnological reactors
• Must acquire knowledge about micro-reactors and their application in biotechnology

• Must acquire knowledge on the underlying principles and the current state of molecular electronics

SKILLS

• Must be able to apply the acquired knowledge to the design and performance evaluation of batch and continuous flow reactors
• Must be able to model chemical and biochemical reactors using COMSOL and other mathematical modeling software

COMPETENCES

• Must have working knowledge and basic skills for designing, modeling and evaluating of chemical, biochemical, and biotechnological reactors
• Must acquire an overview of the current progress in the area of molecular electronics

TYPE OF INSTRUCTION

Lectures and 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	Reaction Engineering and Molecular Electronics
Type of exam	Oral exam
ECTS	5

Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	Besides the evaluation criteria stated in the Joint Programme Regulations, the grade requires participation in presentations and discussions of research papers and completion of an assignment. http://www.engineering.aau.dk/uddannelse/Studieadministration/

FACTS ABOUT THE MODULE

Danish title	Engineering af reaktioner og molekylær elektronik
Module code	F-NB-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	Leonid Gourevitch, Eva Maria Petersen

ORGANISATION

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

MODERN PHYSICS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge in the area of mechanical physics, electromagnetism, and basic quantum mechanics.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Nuclear physics constitutes the foundation for understanding important and societally relevant phenomena like nuclear fission, fusion and radioactivity. In addition, the theory of relativity represent (together with quantum mechanics) key parts of the new paradigm for physics established in the 1900s by replacing the absolute perception of time and space of classical physics with the principle of relativity.

LEARNING OBJECTIVES

KNOWLEDGE

• Should have knowledge about fundamental concepts and theories related to nuclear physics, including the structure of atomic nuclei, nuclear reactions (fission and fusion), as well as radioactivity.
• Should have knowledge about fundamental concepts and theories related to particle physics.

• Should have knowledge about fundamental concepts and theories related to the special theory of relativity.

SKILLS

• Should be able to explain concepts and theories related to the description of nuclear physics.
• Should be able to explain concepts and theories related to the description of particle physics.

• Should be able to explain concepts and theories related to the description of the theory of the special relativity.

COMPETENCES

• Should from the given prerequisites be able to reason and argue using concepts from modern physics and be able to use them on simple model systems.
• Should be able to develop and strengthen knowledge about, as well as, understanding- and application of theories and methods from modern physics within other areas or topics.

TYPE OF INSTRUCTION

Lectures and 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	Modern Physics

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	Moderne fysik
Module code	F-FYS-K1-5
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	Danish and English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Esben Skovsen

ORGANISATION

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

MASTER'S THESIS (60 ECTS)

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The student has the possibility to write a Long Master's Thesis (over 2 semesters), if the thesis is of experimental character. A Long Master's Thesis can be chosen as either 45, 50, or 60 ECTS.
If choosing to do a Long Master's Thesis, the amount of experimental work must reflect the allotted ECTS.

The Master's thesis should be approved by the Board of Studies. It will be done as problem based project work, where the student will develop:

LEARNING OBJECTIVES

KNOWLEDGE

- Knowledge of the subject-specific methods as well as tools applied for the design, fabrication, characterization, and modeling of the biological and organic nanostructures described in the thesis
- Knowledge of the biological, physical, and (bio)chemical principles behind the subject of the thesis

SKILLS

- Ability to approach, describe, and solve a specific problem using the tools available
- Ability to explore and achieve sufficient understanding of the state-of-the-art within the area of the thesis subject
- Ability to define the limits of the project
- Ability to demonstrate scientific and professional project work
- Ability to reflect over the obtained results

COMPETENCES

- Applying the knowledge and skills obtained during the master program to solve the subject specific problem of the thesis with the support of the supervisor
- Evaluate the approach, methods, and materials used for the project to fulfill the goal of the project
- Be able to relate the problem to the relevant field/area and the obtained results
- Be able to make and justify decisions on the relevant theories and methods

TYPE OF INSTRUCTION

Project work.

EXTENT AND EXPECTED WORKLOAD

This is a 60 ECTS project module and the work load is expected to be 1800 hours for the student.

EXAM

EXAMS

Name of exam	Master's Thesis (60 ECTS)
Type of exam	Oral exam based on a project
ECTS	60
Permitted aids	All written and all electronic aids

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 (60 ECTS)
Module code	F-NFM-K3-3
Module type	Project
Duration	2 semesters
Semester	Autumn
ECTS	60
Language of instruction	English
Location of the lecture	Campus Aalborg
Responsible for the module	Peter Fojan

ORGANISATION

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

MASTER'S THESIS (50 ECTS)

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The student has the possibility to write a Long Master's Thesis (over 2 semesters), if the thesis is of experimental character. A Long Master's Thesis can be chosen as either 45, 50, or 60 ECTS. If choosing to do a Long Master's Thesis, the amount of experimental work must reflect the allotted ECTS.

The Master's thesis should be approved by the Board of Studies. It will be done as problem based project work, where the student will develop:

LEARNING OBJECTIVES

KNOWLEDGE

• Either specialist information on one or a few chosen elements of the relevant topic.
• Or broader insight in the topic with regards to theory, methodology, key elements and their mutual contextual relations.

• Or competencies that, in a relevant way, support and expand the actual competence profile of the student.

SKILLS

• Applying nanotechnology.

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 apply critical thinking to evaluate both the chosen theory and methodology, as well as to evaluate the analysis, results and conclusions of the project both during and at the end of the project.

• Presenting relevant academic and professional aspects of the project work in a clear and systematic way.

TYPE OF INSTRUCTION

Project work.

EXTENT AND EXPECTED WORKLOAD

This is a 50 ECTS project module and the work load is expected to be 1500 hours for the student.

EXAM

EXAMS

Name of exam	Master's Thesis (50 ECTS)

Type of exam	Oral exam based on a project
ECTS	50
Permitted aids	All written and all electronic aids
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 (50 ECTS)
Module code	F-NFM-K3-6
Module type	Project
Duration	2 semesters
Semester	Autumn
ECTS	50
Language of instruction	English
Location of the lecture	Campus Aalborg
Responsible for the module	Peter Fojan

ORGANISATION

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

MASTER'S THESIS (45 ECTS)

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The student has the possibility to write a Long Master's Thesis (over 2 semesters), if the thesis is of experimental character. A Long Master's Thesis can be chosen as either 45, 50, or 60 ECTS. If choosing to do a Long Master's Thesis, the amount of experimental work must reflect the allotted ECTS.

Objectives: The Master's thesis should be approved by the Board of Studies. It will be done as problem based project work, where the student will develop:

LEARNING OBJECTIVES

KNOWLEDGE

• Either specialist information on one or a few chosen elements of the relevant topic.
• Or broader insight in the topic with regards to theory, methodology, key elements and their mutual contextual relations.

• Or competencies that, in a relevant way, support and expand the actual competence profile of the student.

SKILLS

• Applying nanotechnology.

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 apply critical thinking to evaluate both the chosen theory and methodology, as well as to evaluate the analysis, results and conclusions of the project both during and at the end of the project.

• Presenting relevant academic and professional aspects of the project work in a clear and systematic way.

TYPE OF INSTRUCTION

Project work.

EXTENT AND EXPECTED WORKLOAD

This is a 45 ECTS project module and the work load is expected to be 1350 hours for the student.

EXAM

EXAMS

Name of exam	Kandidatspeciale (45 ECTS)
Type of exam	Oral exam based on a project
ECTS	45
Permitted aids	All written and all electronic aids
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 (45 ECTS)
Module code	F-NFM-K3-7
Module type	Project
Duration	2 semesters
Semester	Autumn
ECTS	45
Language of instruction	English
Location of the lecture	Campus Aalborg
Responsible for the module	Peter Fojan

ORGANISATION

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