AALBORG UNIVERSITET

STUDIEORDNING FOR KANDIDATUDDANNELSEN I FYSIK OG TEKNOLOGI, 2023

CIVILINGENIØR
AALBORG

MODULER SOM INDGÅR I STUDIEORDNINGEN

INDHOLDSFORTEGNELSE

DESIGN AND ENGINEERING OF NANO- AND MICROSTRUCTURES

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about how to design, model and maybe manufacture different nano – and microstructures.
- Must be able to understand the fundamental concepts of engineering and design of nano – and microstructures.
- Have gained comprehensive knowledge and understanding of processing and/or fabrication of nano – and microscale fabricated materials.
- Have gained comprehensive knowledge and understanding of characterization of nano – and microscale fabricated materials.

SKILLS

- Must be able to apply the design, engineering and manufacturing concepts in order to predict and maybe also fabricate the desired nano – and microstructures.
- Must be able to evaluate the different methods used for production, design, and engineering of nano – and microstructures.
- Be able to apply relevant theories 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 give a critical evaluation of the methods applied for processing and characterizing a material / material system for a given application
- Be able to use methods and tools for processing/fabrication of nano – and microscale materials.
- Compose a project report according to the norms of the scientific field, include relevant original literature and use correct academic language. Be able to communicate the project's research-based basis and problem and results in a coherent written and oral manner, including the connection between the problem formulation, the project's execution and the main conclusions.
- Evaluate and select relevant original literature and current scientific methods, models and other tools used in the project work, as well as assess the project's problem in relevant technical scientific context.

COMPETENCES

- Must have obtained the skills to design, model, fabricate and characterize nano-and microscale structures.
- Be able to set up a realistic and qualitative hypothesis for the outcome of a process.
- Be able to apply method(s) to validate or reject a given hypothesis.
- Be able to use advanced experimental or theoretical methods for processing and characterization.
- Be able to apply the relevant background theory and the insight obtained, for validation of the designed material for a given application.
- Be able to apply the relevant background theory or results from scientific literature in order to design and maybe also fabricate or process materials for specific applications.
- Plan, implement and manage complex and unpredictable research and / or development tasks and assume a professional responsibility for conducting professional and interdisciplinary collaborations.
- Take responsibility for own academic development and specialization.

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	Design and Engineering of Nano- and Microstructures
Type of exam	Oral exam based on a project
ECTS	15
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Design og optimering af nano – og mikrostrukturer
Module code	M-FT-K1-1N
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, Jensen

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Physics and Technology)
Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

ADVANCED GENE TECHNOLOGY

2024/2025

RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge obtained by the module Gene Technology on 5th semester of the Bachelor in Nanotechnology as well as knowledge in Organic Chemistry and Biochemistry.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about advanced gene expression systems.
- Must have knowledge about high throughput screening methods.
- Must have knowledge about advanced applications of gene technology in the areas of biotechnology, medicine, and nanotechnology.

SKILLS

- Must be able to apply the knowledge to solve real world problems.
- Must be able to understand the principles.
- Must be able to engineer (theoretically) new DNA based nano-devices.

COMPETENCES

- Must have a deeper understanding of the principles and tools.
- Must know how to engineer nano-devices for applications in the area of medicine and biotechnology.

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

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	Advanced Gene Technology
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Avanceret genteknologi
Module code	M-NB-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	Evamaria Petersen

ORGANISATION

Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

REACTION ENGINEERING AND MOLECULAR ELECTRONICS

2024/2025

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	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Engineering af reaktioner og molekylær elektronik
Module code	M-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 Gurevich, Evamaria Petersen

ORGANISATION

Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

MOLECULAR SIMULATIONS

2024/2025

RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge obtained in the area of Organic Chemistry, Protein Physics, Basic Quantum Mechanics, and Physical Chemistry.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Students who complete the module: will have gained skills in the up to date computer modeling techniques of molecular dynamics and analysis of in silico modeled protein, peptide and membrane structures and function.

LEARNING OBJECTIVES

KNOWLEDGE

• Must have knowledge about modern force fields.
• Must have knowledge about protein folding and function.

• Must have knowledge about the general building blocks of proteins and their chemistry.

• Must be able to evaluate protein structures.

• Must be able to apply the principals of protein structures and functions to real problems.

SKILLS

• Must be able to apply principals of Molecular dynamics simulations to real problems.
• Must be able to evaluate modeled protein structures and function.

• Must be able to apply the properties and chemistry of the aminoacids to real world problems.

• Must be able to evaluate results from molecular dynamics simulations.

COMPETENCES

• Must have a basic understanding of molecular modelling.
• Must have a general understanding of the physics of protein dynamics and force field based modeling strategies.

• Must have a general knowledge molecular simulations.

TYPE OF INSTRUCTION

Lectures with accompanying problem solving session.

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	Molecular Simulations
Type of exam	Active participation/continuous evaluation The re-exam will be written or oral.
ECTS	5
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Molekylær simulering
Module code	M-NB-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	Fojan

ORGANISATION

Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

PRODUCTION AND CHARACTERIZATION OF NANO- AND MICROSTRUCTURES

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about methods and tools used for production and characterization of nano – and microstructures.
- Must be able to understand the fundamental concepts behind the methods and tools used for production and characterization of nano – and microstructures.
- Have gained comprehensive knowledge and understanding of fabrication and/or modelling used in the area of nano – and microscale materials.

SKILLS

- Must be able to produce nano - and microstructures and investigate their properties using relevant methods and tools.
- Must be able to evaluate the different methods used for production and characterization of nano – and microstructures.
- 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 nano - or microstructured 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 nano – and microstructured materials.
- Compose a project report according to the norms of the scientific field, include relevant original literature and use correct academic language. Be able to communicate the project's research-based basis and problem and results in a coherent written and oral manner, including the connection between the problem formulation, the project's execution and the main conclusions.
- Evaluate and select relevant original literature and current scientific methods, models and other tools used in the project work, as well as assess the project's problem in relevant technical scientific context.

COMPETENCES

- Must have obtained the skills to produce and characterize nano – and microstructures by using relevant tools and methods.
- Be able to apply experimental methods and/or numerical models to validate a given hypothesis.
- Be able to use advanced experimental and/or numerical techniques within the field of nano – and micro-structured materials.
- Be able to apply the background theory and the insight obtained, to synthesize and/or model materials for a given application.
- Plan, implement and manage complex and unpredictable research and / or development tasks and assume a professional responsibility for conducting professional and interdisciplinary collaborations.
- Take responsibility for own academic development and specialization.

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	Production and Characterization of Nano- and Microstructures
Type of exam	Oral exam based on a project
ECTS	15
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Produktion og karakterisering af nano-og mikrostrukurer
Module code	M-FT-K2-1N
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	Rauhe

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Physics and Technology)
Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

SELF-ASSEMBLING SYSTEMS

2024/2025

RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge obtained in the area of Physical Chemistry, Inorganic and Organic Chemistry, and Biochemistry.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

• Must acquire knowledge about basic principles of self-assmbling behavior in nature, forces involved in the process, ways to model and design a self-assembling system
• Must acquire knowledge about application of self-assembly for drug-delivery, thin films and nano-arrays

SKILLS

• Must be able to use Langmuir-Blodgett technique as well as other methods to fabricate monolayers, micelles and vesicles
• Must be able to apply the acquired knowledge to critically read and understand research papers on the subject of self-assembly

COMPETENCES

• Must acquire an overview of the current progress in the areas of self-assembly and drug delivery

TYPE OF INSTRUCTION

Lectures and exercises.

EXAM

EXAMS

Name of exam	Self-Assembling Systems
Type of exam	Written or oral exam
ECTS	5
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Selvorganiserende biostrukturer
Module code	F-NB-K2-2
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	Leonid Gurevich, Fojan

ORGANISATION

Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

NMR OG MS

2024/2025

MODULETS INDHOLD, FORLØB OG PÆDAGOGIK

LÆRINGSMÅL

VIDEN

Studerende, der gennemfører modulet, skal kunne

- redegøre for de teoretiske grundlag for NMR og MS, herunder også hvordan de observerede signaler opstår
- redegøre for forskellige typer NMR og MS eksperimenter og den information, de hver især giver
- redegøre for den eksperimentelle fremgangsmåde ved måling af NMR og MS data

FÆRDIGHEDER

- behandle NMR data, herunder processere og præsentere 1D og 2D NMR spektre
- fortolke 1D og 2D NMR spektre, herunder være i stand til at forudsige spektre fra en given molekylestruktur, finde et ukendt molekyles struktur ud fra et givent spektrum, være i stand til at tilordne NMR signaler til atomer i et molekyle eller foretage kvantitative beregninger på baggrund af NMR data.
- fortolke MALDI MS, EI MS og ESI MS spektre
- benytte korrekte begreber, notationer og symboler fra NMR og MS litteraturen

KOMPETENCER

- vurdere anvendeligheden af NMR og MS på kemiske bioteknologiske og nanoteknologiske problemstillinger
- fremlægge kemiske, bioteknologiske og nanoteknologiske resultater på baggrund af NMR og MS data

UNDERVISNINGSFORM

- Forelæsninger
- Teoretiske øvelser

OMFANG OG FORVENTET ARBEJDSINDSATS

150 arbejdstimer

EKSAMEN

PRØVER

Prøvens navn	NMR og MS
Prøveform	Skriftlig eller mundtlig
ECTS	5
Tilladte hjælpemidler	Med visse hjælpemidler: Der henvises til eksamensplanen.
Bedømmelsesform	7-trins-skala
Censur	Intern prøve
Vurderingskriterier	Vurderingskriterierne er angivet i Universitetets eksamensordning

FAKTA OM MODULET

Engelsk titel	NMR and MS
Modulkode	K-BT-B6-14A
Modultype	Kursus
Varighed	1 semester
Semester	Forår
ECTS	5
Undervisningssprog	Engelsk
Tomplads	Ja
Undervisningssted	Campus Aalborg
Modulansvarlig	Wimmer

ORGANISATION

Studienævn	Studienævn for Kemi og Biovidenskab
Institut	Institut for Kemi og Biovidenskab
Fakultet	Det Ingeniør- og Naturvidenskabelige Fakultet

OVERFLADEFYSIK OG -KEMI (B)

2024/2025

ANBEFALEDE FAGLIGE FORUDSÆTNINGER FOR AT DELTAGE I MODULET

Modulet bygger på viden opnået i faststoffysik, grund- og fysiskkemi.

MODULETS INDHOLD, FORLØB OG PÆDAGOGIK

Kursets mål er, at give viden om specielle aspekter samt fysiske og kemiske fænomener på overflader og grænseflader.

LÆRINGSMÅL

VIDEN

- struktur af krystalliske overflader samt metoder og teknologier indenfor fremstilling og karakterisering
- grundlæggende termodynamik og kinetik af overfladeprocesser herunder fænomener om overfladespænding og adsorption/desorption
- de vigtigste interaktioner nær grænsefladerne herunder van der Waals og dobbelt-lags kræfter
- fysi- og kemisorption på overflader og katalyse
- struktur af grænseflader, befugtning teori, hydrofobicitet, membraner og vækst af tynde film
- elektronisk struktur af overflader, elektriske og magnetiske fænomener på overflader og grænseflader;

FÆRDIGHEDER

Den studerende vil blive uddannet i at løse problemer inden for de emner, der er anført ovenfor, og vil være i stand til at anvende teorier og metoder fra overfladefysik og -kemi.

KOMPETENCER

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

UNDERVISNINGSFORM

Forelæsninger med tilhørende opgaveregning.

OMFANG OG FORVENTET ARBEJDSINDSATS

Kursusmodulets omfang er 5 ECTS svarende til 150 timers studieindsats.

EKSAMEN

FORUDSÆTNING FOR INDSTILLING TIL PRØVEN

- Aflevering/oplæg og godkendelse af opgaver er en forudsætning for deltagelse i eksamen.

PRØVER

Prøvens navn	Overfladefysik og -kemi
Prøveform	Skriftlig eller mundtlig

ECTS	5
Bedømmelsesform	7-trins-skala
Censur	Intern prøve
Vurderingskriterier	Vurderingskriterierne er angivet i Universitetets eksamensordning

FAKTA OM MODULET

Engelsk titel	Physics and Chemistry of Surfaces
Modulkode	F-FYS-K2-5A
Modultype	Kursus
Varighed	1 semester
Semester	Forår
ECTS	5
Undervisningssprog	Engelsk
Tomplads	Ja
Undervisningssted	Campus Aalborg
Modulansvarlig	Leonid Gurevich, Vladimir Popok

ORGANISATION

Studienævn	Studienævn for Mekanik og Fysik
Institut	Institut for Materialer og Produktion
Fakultet	Det Ingeniør- og Naturvidenskabelige Fakultet

ADVANCED NANOBIOTECHNOLOGY

2024/2025

RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge obtained by the project on NB2 (2nd semester).

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

This project focuses on all kinds of advanced biostructures and their static and dynamic properties.

Different advanced nanobiostructures will be manufactured and/or modeled and their static and dynamic properties will be characterized using state-of-the-art scientific tools, techniques and theories.

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.
- Knowledge of the biological, physical, and (bio)chemical principles behind the subject.

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 methods and principles used in the project.
- Ability to define the limits of the project.
- Ability to reflect over the obtained results.
- Compose a project report according to the norms of the scientific field, include relevant original literature, use correct academic language and communicate the project's research-based basis and problem and results in a coherent written and oral manner, including the connection between the problem formulation, the project's execution and the main conclusions.
- Evaluate and select relevant original literature and current scientific methods, models and other tools used in the project work, as well as assess the project's problem in relevant technical scientific context.

COMPETENCES

- Should be able to identify, formulate, and analyze independently a problem.
- Should have the necessary skills to identify and apply the relevant scientific theories and methods to the formulated problem.
- Plan, implement and manage complex and unpredictable research and / or development tasks and assume a professional responsibility for conducting professional and interdisciplinary collaborations.
- Take responsibility for own academic development and specialization.

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 Nanobiotechnology
Type of exam	Oral exam based on a project
ECTS	20
Permitted aids	All written and all electronic aids
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Avanceret Nanobioteknologi
Module code	M-NB-K3-2
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	20
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Fojan

ORGANISATION

Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

MATERIALS CHEMISTRY

2024/2025

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

- explain 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

TYPE OF INSTRUCTION

- Lectures
- Workshops
- Excercises (individually and in groups)

EXTENT AND EXPECTED WORKLOAD

150 hours

EXAM

EXAMS

Name of exam	Materials Chemistry
Type of exam	Written or oral exam
ECTS	5
Permitted aids	With certain aids: Please refer to the exam plan.
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

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	Yue

ORGANISATION

Study Board	Study Board of Chemistry and Bioscience
Department	Department of Chemistry and Bioscience
Faculty	The Faculty of Engineering and Science

MATERIALS CHARACTERIZATION

2024/2025

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	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

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

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	Jensen

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Materials and Nanotechnology)
Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

ADVANCED NANOBIOTECHNOLOGY

2024/2025

RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge obtained by the project on NB2 (2nd semester).

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

This project focuses on all kinds of advanced biostructures and their static and dynamic properties.

Different advanced nanobiostructures will be manufactured and/or modeled and their static and dynamic properties will be characterized using state-of-the-art scientific tools, techniques and theories.

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.
- Knowledge of the biological, physical, and (bio)chemical principles behind the subject.

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 methods and principles used in the project.
- Ability to define the limits of the project.
- Ability to reflect over the obtained results.
- Compose a project report according to the norms of the scientific field, include relevant original literature, use correct academic language and communicate the project's research-based basis and problem and results in a coherent written and oral manner, including the connection between the problem formulation, the project's execution and the main conclusions.
- Evaluate and select relevant original literature and current scientific methods, models and other tools used in the project work, as well as assess the project's problem in relevant technical scientific context.

COMPETENCES

- Should be able to identify, formulate, and analyze independently a problem.
- Should have the necessary skills to identify and apply the relevant scientific theories and methods to the formulated problem.
- Plan, implement and manage complex and unpredictable research and / or development tasks and assume a professional responsibility for conducting professional and interdisciplinary collaborations.
- Take responsibility for own academic development and specialization.

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 Nanobiotechnology
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	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Avanceret Nanobioteknologi
Module code	M-NB-K3-3
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	Fojan

ORGANISATION

Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

ADVANCED NANOBIOTECHNOLOGY

2024/2025

RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge obtained by the project on NB2 (2nd semester).

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

This project focuses on all kinds of advanced biostructures and their static and dynamic properties.

Different advanced nanobiostructures will be manufactured and/or modeled and their static and dynamic properties will be characterized using state-of-the-art scientific tools, techniques and theories.

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.
- Knowledge of the biological, physical, and (bio)chemical principles behind the subject.

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 methods and principles used in the project.
- Ability to define the limits of the project.
- Ability to reflect over the obtained results.
- Compose a project report according to the norms of the scientific field, include relevant original literature, use correct academic language and communicate the project's research-based basis and problem and results in a coherent written and oral manner, including the connection between the problem formulation, the project's execution and the main conclusions.
- Evaluate and select relevant original literature and current scientific methods, models and other tools used in the project work, as well as assess the project's problem in relevant technical scientific context.

COMPETENCES

- Should be able to identify, formulate, and analyze independently a problem.
- Should have the necessary skills to identify and apply the relevant scientific theories and methods to the formulated problem.
- Plan, implement and manage complex and unpredictable research and / or development tasks and assume a professional responsibility for conducting professional and interdisciplinary collaborations.
- Take responsibility for own academic development and specialization.

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 Nanobiotechnology
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	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Avanceret Nanobioteknologi
Module code	M-NB-K3-4
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	Fojan

ORGANISATION

Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

PROJECT-ORIENTED STUDY IN AN EXTERNAL ORGANISATION

2024/2025

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:
    - Empirical background
    - Research problem/project objective
    - Relevant theory
    - Research design
    - Presentation of data
    - Presentation and discussion of findings
    - Evaluation of the project; i.e., findings, methods and, if relevant, considerations regarding the limitations and generalizability of the study.

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	Project-oriented Study in an External Organisation
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	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Projektorienteret forløb i en virksomhed
Module code	M-NB-K3-5
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	30
Language of instruction	English
Location of the lecture	Campus Aalborg
Responsible for the module	Thomas Møller Søndergaard

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Nanobiotechnology)
Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

MASTER'S THESIS

2024/2025

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.
- Build a project report according to the field's norms, use correct professional language, document extensive inclusion of relevant original literature, communicate and discuss the project's research-based basis and problem and results in a written, graphic and oral manner in a coherent way.
- Critically evaluate the project's results in relation to relevant original literature and current scientific methods, models and evaluate and discuss the project's problem in relevant technical scientific context.
- Perspective and assess the project's potential for further development.

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.
- Perform planning, implementation and management of complex and unpredictable research and / or development tasks and assume a professional responsibility for completing independent academic tasks as well as interdisciplinary collaborations.
- Independently take responsibility for own professional development and specialization.

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

The master thesis can be conducted as a long master thesis. If choosing to do a long master thesis, it has to include experimental work and has to be approved by the study board. The amount of experimental work must reflect the allotted ECTS.

Since it is a 50 ECTS project module the expected workload is 1.500 hours for the student.

EXAM

EXAMS

Name of exam	Master's Thesis
Type of exam	Master's thesis/final project
ECTS	50
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Kandidatspeciale
Module code	M-FT-K4-2
Module type	Project
Duration	2 semesters
Semester	Spring
ECTS	50
Language of instruction	English
Location of the lecture	Campus Aalborg
Responsible for the module	Jørgen Asbøll Kepler

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Physics and Technology)
Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

MASTER'S THESIS

2024/2025

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.
- Build a project report according to the field's norms, use correct professional language, document extensive inclusion of relevant original literature, communicate and discuss the project's research-based basis and problem and results in a written, graphic and oral manner in a coherent way.
- Critically evaluate the project's results in relation to relevant original literature and current scientific methods, models and evaluate and discuss the project's problem in relevant technical scientific context.
- Perspective and assess the project's potential for further development.

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.
- Perform planning, implementation and management of complex and unpredictable research and / or development tasks and assume a professional responsibility for completing independent academic tasks as well as interdisciplinary collaborations.
- Independently take responsibility for own professional development and specialization.

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

The master thesis can be conducted as a long master thesis. If choosing to do a long master thesis, it has to include experimental work and has to be approved by the study board. The amount of experimental work must reflect the allotted ECTS.

Since it is a 60 ECTS project module the expected workload is 1.800 hours for the student.

EXAM

EXAMS

Name of exam	Master's Thesis
Type of exam	Master's thesis/final project
ECTS	60
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Kandidatspeciale
Module code	M-FT-K4-3
Module type	Project
Duration	2 semesters
Semester	Spring
ECTS	60
Language of instruction	English
Location of the lecture	Campus Aalborg
Responsible for the module	Jørgen Asbøll Kepler

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Physics and Technology)
Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

MASTER'S THESIS

2024/2025

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.
- Build a project report according to the field's norms, use correct professional language, document extensive inclusion of relevant original literature, communicate and discuss the project's research-based basis and problem and results in a written, graphic and oral manner in a coherent way.
- Critically evaluate the project's results in relation to relevant original literature and current scientific methods, models and evaluate and discuss the project's problem in relevant technical scientific context.
- Perspective and assess the project's potential for further development.

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.
- Perform planning, implementation and management of complex and unpredictable research and / or development tasks and assume a professional responsibility for completing independent academic tasks as well as interdisciplinary collaborations.
- Independently take responsibility for own professional development and specialization.

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
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Kandidatspeciale
Module code	M-MN-K4-1A
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	30
Language of instruction	English
Location of the lecture	Campus Aalborg
Responsible for the module	Lars Diekhöner, Jensen

ORGANISATION

Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

NUMERISKE METODER

2024/2025

ANBEFALEDE FAGLIGE FORUDSÆTNINGER FOR AT DELTAGE I MODULET

Modulet bygger videre på viden opnået i ”Anvendt ingeniørmatematik" eller lignende.

MODULETS INDHOLD, FORLØB OG PÆDAGOGIK

LÆRINGSMÅL

VIDEN

- Have viden og forståelse for grundlæggende numeriske metoder indenfor maskinteknik, energiteknik og byggeteknik.
- Have viden og forståelse for numeriske metoder til løsning af systemer af lineære og ikke-lineære ligninger.
- Have viden om matrix egenværdiproblemer.
- Have viden og forståelse for interpolationsmetoder.
- Have viden og forståelse for numeriske integrationsmetoder.
- Have viden og forståelse for numeriske metoder til første og anden ordens ordinære differentialligninger.
- Have viden og forståelse for elliptiske, parabolske og hyperbolske partielle differentialligninger samt brugen af disse indenfor ingeniørområdet.
- Have viden og forståelse for numerisk løsning af partielle differentialligninger ved brug af differensmetoder, finite volume metoder og finite element metoder, samt have viden om brugen af disse metoder til ingeniørmæssige problemer.

FÆRDIGHEDER

- Skal kunne anvende numeriske metoder til at løse lineære ligningssystemer ved brug af direkte og iterative løsningsmetoder.
- Skal kunne løse en ikke-lineær ligning og systemer af ikke-lineære ligninger ved brug af numeriske metoder.
- Skal kunne estimere og beregne egenværdier og egenvektorer af en matrix.
- Skal kunne anvende forskellige metoder til interpolation af data.
- Skal kunne anvende forskellige metoder til numerisk løsning af bestemte integraler.
- Skal kunne løse første og anden ordens ordinære differentialligninger ved brug af numeriske metoder.
- Skal kunne anvende analytiske metoder til at løse partielle differentialligninger.
- Skal kunne anvende differensmetoder til at løse elliptiske, parabolske og hyperbolske partielle differentialligninger.
- Skal kunne anvende finite volume metoden til at løse diffusionsligninger.
- Skal kunne anvende finite element metoden til at løse diffusionsligninger.
- Skal kunne anvende computerprogrammet MATLAB til de numeriske metoder dækket i kurset.

KOMPETENCER

- Skal kunne håndtere udviklingsorienterede situationer i forbindelse med numeriske metoder i studie- eller arbejdssammenhænge.
- Skal selvstændigt kunne indgå i fagligt og tværfagligt samarbejde med en professionel tilgang inden for matematiske numeriske metoder.
- Skal kunne identificere egne læringsbehov og strukturere egen læring inden for numeriske metoder.

UNDERVISNINGSFORM

Undervisningen tilrettelægges i henhold til de generelle undervisningsformer for uddannelsen, jf. studieordningens §17.

OMFANG OG FORVENTET ARBEJDSINDSATS

Da det er et 5 ECTS kursus forventes der en arbejdsbyrde på 150 timer.

EKSAMEN

PRØVER

Prøvens navn	Numeriske metoder
Prøveform	Skriftlig eller mundtlig
ECTS	5
Tilladte hjælpemidler	Oplysninger om tilladte hjælpemidler til eksamen offentliggøres under beskrivelsen af semesteret/kurset.
Bedømmelsesform	7-trins-skala
Censur	Intern prøve
Vurderingskriterier	Vurderingskriterierne er angivet i Universitetets eksamensordning

FAKTA OM MODULET

Engelsk titel	Numerical Methods
Modulkode	M-MP-B5-3B
Modultype	Kursus
Varighed	1 semester
Semester	Efterår og Forår
ECTS	5
Undervisningssprog	Engelsk
Tomplads	Ja
Undervisningssted	Campus Aalborg, Campus Esbjerg
Modulansvarlig	Lund, Thomas Condra

ORGANISATION

Uddannelsesejer	Civilingeniør, cand.polyt. i indeklima og energi
Studienævn	Studienævn for Mekanik og Fysik
Institut	Institut for Materialer og Produktion
Fakultet	Det Ingeniør- og Naturvidenskabelige Fakultet

HALVLEDERE: FYSIK, KOMPONENTER OG TEKNOLOGI

2024/2025

ANBEFALEDE FAGLIGE FORUDSÆTNINGER FOR AT DELTAGE I MODULET

Modulet bygger på viden opnået i faststoffysik, grundlæggende kvantemekanik.

MODULETS INDHOLD, FORLØB OG PÆDAGOGIK

Kursets mål er at give en forståelse af halvlederegenskaber, principper for funktion af vigtige halvlederkomponenter samt viden om metoder til syntese af halvledermaterialer og grundlæggende teknologier inden for fabrikation af komponenter.

LÆRINGSMÅL

VIDEN

• Skal have viden om krystalstruktur og karakteristiske egenskaber af halvledere
• Skal have viden om elektronisk båndstruktur af halvledere, både for intrinsiske og doterede halvledere samt ladningsbærerstatistik og -dynamik

• Skal have viden om grundlæggende komponenters karakteristika, herunder PN-overgange, bipolar transistorer, metaloxid-halvlederkomponenter og komponenter for effektelektronik

• Skal have viden om grundlæggende metoder og teknologier indenfor fabrikation af halvlederkomponenter

FÆRDIGHEDER

• Skal kunne redegøre for og anvende teorier og metoder for beskrivelse af halvlederes egenskaber, herunder krystalstruktur, elektroniske egenskaber af intrinsiske og doterede halvledere, og ladningsbærerstatistik og -dynamik
• Skal kunne redegøre for grundlæggende halvlederbaserede komponenters egenskaber og karakteristika samt teknologier indenfor fabrikation af halvlederkomponenter

KOMPETENCER

Kompetencerne som opnås, skal udvikle og styrke kendskab til egenskaber af havledere og de grundlæggende principper og teknologier der ligger bag halvlederbaserede komponenter. Den studerende skal ud fra givne forudsætninger kunne ræsonnere og argumentere med begreber fra halvlederfysik og teknologi.

UNDERVISNINGSFORM

Forelæsninger med opgaveregning.

OMFANG OG FORVENTET ARBEJDSINDSATS

Kursusmodulets omfang er 5 ECTS svarende til 150 timers studieindsats.

EKSAMEN

FORUDSÆTNING FOR INDSTILLING TIL PRØVEN

- Aflevering af et antal opgaver i forbindelse med kurset.

PRØVER

Prøvens navn	Halvledere: fysik, komponenter og teknologi
Prøveform	Skriftlig eller mundtlig
ECTS	5
Bedømmelsesform	7-trins-skala
Censur	Intern prøve
Vurderingskriterier	Vurderingskriterierne er angivet i Universitetets eksamensordning

FAKTA OM MODULET

Engelsk titel	Semiconductors: Physics, Devices and Engineering
Modulkode	F-FYS-K3-9
Modultype	Kursus
Varighed	1 semester
Semester	Efterår
ECTS	5
Undervisningssprog	Engelsk
Tomplads	Ja
Undervisningssted	Campus Aalborg
Modulansvarlig	Vladimir Popok

ORGANISATION

Uddannelsesejer	Cand.scient. i fysik
Studienævn	Studienævn for Mekanik og Fysik
Institut	Institut for Materialer og Produktion
Fakultet	Det Ingeniør- og Naturvidenskabelige Fakultet

QUANTUM MATERIALS AND OPTICAL NANOSTRUCTURES

2024/2025

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, including analytic calculation and numerical computermodeling

SKILLS

- The student must be able to apply the knowledge in above mentioned areas for solving problems in said areas (analytically and numerically), 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
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Kvantematerialer og optiske nanostrukturer
Module code	F-NFM-K2-3A
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	Thomas Møller Søndergaard

ORGANISATION

Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

SELECTED TOPICS IN PHYSICS AND MATERIALS SCIENCE

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

As part of a research-based education students will get insight into current/state-of-the-art research activities at the department as well as new results from recent literature. The students will be presented with methods and results within a broad range of research and development relevant for the line of study. As part of the evaluation of the course students will learn how to present scientific results. Thus, the course serves to provide an introduction to recent topics, as well as introducing good practice in reading/reviewing and otherwise critically assessing recent research.

LEARNING OBJECTIVES

KNOWLEDGE

- Knowledge on various topics in physics and materials science based on recent research activities.

SKILLS

- Identifying, reading and reviewing scientific papers on recent topics.
- Summarizing and presenting scientific research (methods and results).
- Identify specific methods as well as overall methodical approaches

COMPETENCES

- The student will gain insight into professional scientific communication (oral and written) of scientific methods, achievements, and results within selected fields in direct relation to their line of study.
- The student will be able to search for, identify and critically assess recent scientific publications in terms of communicative clarity, reproducibility of observations, falsifiability of hypotheses

TYPE OF INSTRUCTION

Lectures combined with exercises and discussions with lecturers.

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	Selected Topics in Physics and Materials Science
Type of exam	Active participation/continuous evaluation Student participation will be registered during each teaching/discussion session. Passed/not passed, based on at least 80% active participation. Reexamination is conducted as oral or written exam.
ECTS	5
Assessment	Passed/Not Passed

Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Udvalgte emner inden for fysik og materialevidenskab
Module code	M-FT-K2-2
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Language of instruction	English
Location of the lecture	Campus Aalborg
Responsible for the module	Lars Diekhöner

ORGANISATION

Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

MATERIALS ENGINEERING

2024/2025

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.
- Explain the scientific basis and scientific issues within the specialization.
- Explain the highest international research in the field of specialization.

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.
- Master the scientific methods and general skills related to the field of specialization
- Compose a project report according to the field's norms, use correct professional language, document extensive inclusion of relevant original literature, communicate and discuss the project's research-based basis and problem and results in a written, graphic and oral manner in a coherent way.
- Critically evaluate the project's results in relation to relevant original literature and current scientific methods, models and evaluate and discuss the project's problem in a relevant technical scientific context.
- Assess and put the project's potential into perspective for further development.

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.
- Participate in and independently carry out technological development and research, as well as solve complex tasks using scientific methods.
- Perform planning, implementation and management of complex and unpredictable research and / or development tasks and assume a professional responsibility for completing independent academic tasks as well as interdisciplinary collaborations.
- Independently take responsibility for own professional development and 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
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Materialeudvikling
Module code	M-MN-K3-1A
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	Lars Diekhöner, Jensen

ORGANISATION

Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

MATERIALS ENGINEERING

2024/2025

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.
- Explain the scientific basis and scientific issues within the specialization.
- Explain the highest international research in the field of specialization.

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.
- Master the scientific methods and general skills related to the field of specialization
- Compose a project report according to the field's norms, use correct professional language, document extensive inclusion of relevant original literature, communicate and discuss the project's research-based basis and problem and results in a written, graphic and oral manner in a coherent way.
- Critically evaluate the project's results in relation to relevant original literature and current scientific methods, models and evaluate and discuss the project's problem in a relevant technical scientific context.
- Assess and put the project's potential into perspective for further development.

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.
- Participate in and independently carry out technological development and research, as well as solve complex tasks using scientific methods.
- Perform planning, implementation and management of complex and unpredictable research and / or development tasks and assume a professional responsibility for completing independent academic tasks as well as interdisciplinary collaborations.
- Independently take responsibility for own professional development and 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
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Materialeudvikling
Module code	M-MN-K3-2A
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	Lars Diekhöner, Jensen

ORGANISATION

Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

PROJECT ORIENTED STUDY IN AN EXTERNAL ORGANISATION

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The Project-Oriented Study in an External Organisation must have a scope that corresponds to the ECTS load.

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
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

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	Rauhe

ORGANISATION

Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

PROJECT ORIENTED STUDY IN AN EXTERNAL ORGANISATION

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The Project-Oriented Study in an External Organisation must have a scope that corresponds to the ECTS load.

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
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

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	Rauhe

ORGANISATION

Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

FRACTURE MECHANICS AND FATIGUE

2024/2025

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
Permitted aids	Information about allowed helping aids for the examination will be published in the description of the semester/module.
Assessment	7-point grading scale

Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

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	Andreasen

ORGANISATION

Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

FINITE ELEMENT METHODS

2024/2025

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
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

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	Lund

ORGANISATION

Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science

SOLID STATE PHYSICS II: ELECTRONIC STRUCTURE

2024/2025

RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module adds to the knowledge obtained in the modules Introduction to Mechanics and Thermodynamics, Linear algebra, Calculus, Solid State Physics I: Geometric Structure and Introduction to Quantum Mechanics.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Students completing the module will gain insight into the electronic and magnetic properties of solids as well as a number of phenomena that occur in solids when one or more dimensions are at the nanoscale.

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge of basic concepts and theories regarding the electronic structure of solids, both metals and semiconductors
- Must have knowledge of methods for calculating electronic band structure and band gap
- Must have knowledge of magnetic properties of solids, including a microscopic description of dia-, para- and ferromagnetism.
- Must have knowledge of the electronic and magnetic properties of selected nanostructures

SKILLS

- Be able to explain and apply basic concepts and theories regarding the electronic structure of solids, both metals and semiconductors
- Must be able to explain theories and methods for calculating electronic band structure in solids
- Must be able to explain theories for the calculation of magnetic properties of solids

COMPETENCES

The competencies gained must develop and strengthen knowledge, understanding and application of theories and methods in solid state physics. Based on given prerequisites, the student must be able to reason and argue using concepts from solid state physics

TYPE OF INSTRUCTION

Please see §17 in the curriculum.

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course the expected work load is 150 hours.

EXAM

EXAMS

Name of exam	Solid State Physics II: Electronic Structure
Type of exam	Oral exam
ECTS	5

Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	The criteria of assessment are stated in the Examination Policies and Procedures

FACTS ABOUT THE MODULE

Danish title	Faststoffysik II: Elektronisk struktur
Module code	F-FYS-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	Lars Diekhöner

ORGANISATION

Study Board	Study Board of Mechanical Engineering and Physics
Department	Department of Materials and Production
Faculty	The Faculty of Engineering and Science