AALBORG UNIVERSITET

STUDIEORDNING FOR KANDIDATUDDANNELSEN I ROBOTTEKNOLOGI, 2023

CIVILINGENIØR
AALBORG

MODULER SOM INDGÅR I STUDIEORDNINGEN

INDHOLDSFORTEGNELSE

ADVANCED MOBILE ROBOTICS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Objective:

An important class of robots are mobile robots. A mobile robotic system needs sensing, decision making and propulsion. To this end, this project-module will teach the students how to analyse and implement these capabilities into a mobile robotic application.

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge of terminology within mobile robotics
- Must have knowledge of different categories of mobile robotic systems
- Must be able to understand how a particular mobile robotic system e.g. the semester project of the student, relates to similar systems
- Must demonstrate knowledge of common strategies for sensing, guidance and control of mobile robotic systems
- Must understand the scientific communication processes related to conference presentations and related to publishing in peer-reviewed scientific journals
- Must know how to organize a scientific publication

SKILLS

- Must be able to analyse a problem and suggest a solution that uses relevant theories and methods from mobile robotics
- Must be able to analyse a mobile robotic system and identify relevant constraints and assessment criteria
- Must be able to analyse and implement algorithms (e.g., sensing, path planning, localization, control etc.) of relevance to the chosen mobile robotic system
- Must be able to synthesize, i.e., design and implement, a system (or parts hereof) using relevant theories and methods from mobile robotics
- Must be able to evaluate a mobile robotic system (or parts hereof) with respect to specific assessment criteria
- Can explain the process of and criteria for peer reviewed scientific communications
- Can write a paper for a scientific conference/journal
- Can prepare and give an oral and poster presentation for a scientific conference

COMPETENCES

- Must be able to select relevant mobile robotic theories, methods, and tools, and synthesize them in a new context to produce new knowledge and solutions
- Must be able to read and understand selected scientific literature and then apply the theories, methods, and/or tools in order to solve a problem
- Must be able to present the problem, the suggested solution(s), experiments and simulation results, as well as the overall conclusion in terms of a scientific paper and a poster
- Must be able to present orally the main contribution and conclusion of the work in terms of a 15 minutes conference presentation
- Are able to judge and prioritize the validity of various sources of sciencetific information
- Can apply internationally recognized principles for acknowledging and citing work of others properly
- Can formulate and explain scientific hypotheses and results achieved through scientific work
- Are able to analyze results and draw conclusions on a scientific basis

TYPE OF INSTRUCTION

Project work

EXAM

EXAMS

Name of exam	Advanced Mobile Robotics
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	Avancerede mobile robotter
Module code	ESNROBK1P3
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	Madsen

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Robotics)
Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	The Technical Faculty of IT and Design

ROBOT NAVIGATION

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Objective:

A mobile robotic system needs to be able to navigate in its environment. This course will teach the students how to self-localize using a combination of sensors, and plan paths and trajectories in order to avoid obstacles.

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge of sensors for self-localization and obstacle avoidance
- Must have knowledge of map building, internal representations of maps and interpretation of maps
- Must be able to understand the principles of simultaneous localization and mapping

SKILLS

- Must be able to select appropriate sensors or combination of sensors for a specific robot task
- Must be able to combine noisy and imperfect sensor data into a robot pose estimate
- Must be able to implement algorithms for generating paths and/or trajectories towards specified goals
- Must be able to decompose mission objectives into subtasks using state-diagrams or similar and implement algorithms for executing tasks

COMPETENCES

- Must be able to localize and plan a path or trajectory for a specific robot in a complex dynamic environment

TYPE OF INSTRUCTION

See the general description of the types of instruction described in § 17.

EXAM

EXAMS

Name of exam	Robot Navigation
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	Robot navigation
Module code	ESNROBK1K1

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	Madsen

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Robotics)
Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	The Technical Faculty of IT and Design

ROBOT MOBILITY

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Objective:

Mobile robots use their motors and sensors to move around. This course focuses on theories and methods relating to modelling, simulating and controlling mobile robotic systems.

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about mobile robot models, including holonomic and non-holonomic constraints
- Must have knowledge of different categories of mobile robots, such as unmanned aerial vehicles, autonomous boats, omnidirectional vehicles, car-like robots, powered wheelchairs etc.
- Must be able to understand principles of motion coordination between mobile robots
- Must have knowledge of common guidance and control strategies for mobile robots

SKILLS

- Must be able to build and simulate kinematic and dynamic models of mobile robots
- Must be able to follow generated paths or trajectories towards a goal
- Must be able to formulate multivariable control problems in the context of robot mobility

COMPETENCES

- Must be able to model and simulate systems of mobile robots in an environment populated with obstacles
- Must be able to design control systems for mobile robots

TYPE OF INSTRUCTION

Types of instruction are listed in §17; Structure and Contents of the Programme.

EXAM

EXAMS

Name of exam	Robot Mobility
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	Robot mobilitet
Module code	ESNROBK1K2

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	Madsen

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Robotics)
Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	The Technical Faculty of IT and Design

ADVANCED ROBOTIC PERCEPTION

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Objective:

A robotic system needs an awareness of its context, i.e. objects and people in its vicinity. To this end, this course will teach the students how to use computer vision and pattern recognition methods to estimate the type of objects in the surroundings and the whereabouts of people nearby.

LEARNING OBJECTIVES

KNOWLEDGE

- Must be able to explain the principles behind robust feature point algorithms
- Must have knowledge of feature selection and reduction methods
- Must have knowledge of motion analysis principles
- Must be able to understand tracking frameworks
- Must be able to understand how advanced perception is integrated into robotic systems (e.g visual servoing, obstacle avoidance)

SKILLS

- Must be able to apply sliding window approaches based on advanced features to detect objects
- Must be able to apply stereo vision to generate 3D data from two or more cameras
- Must be able to apply model-based approaches to estimate the 3D pose of objects and people
- Must be able to apply pattern recognition methods to classify object types and activities
- Must be able to integrate advanced perception into robotic systems

COMPETENCES

- Must be able to analyse a specific problem within mobile robotics and based upon this select, implement and evaluate an appropriate computer vision approach

TYPE OF INSTRUCTION

See the general description of the types of instruction described in § 17.

EXAM

EXAMS

Name of exam	Advanced Robotic Perception
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 robot perception
Module code	MSNROBK1231
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	Madsen

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Robotics)
Study Board	Study Board of Media Technology
Department	Department of Architecture, Design and Media Technology
Faculty	The Technical Faculty of IT and Design

COLLABORATIVE ROBOTICS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Objective:

Collaborative robots, are robots that are designed to work with humans or together. The objective of this project is to provide students with core competencies within the field of collaborative robotics and hereby enabling them to analyse, design and implement robotic systems that interact and/or integrate with humans.

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about the terminology within collaborative robotics
- Must be able to understand how a particular collaborative robotic system e.g. the semester project of the student, relates to similar systems and, if relevant, to the human body and/or the surrounding society
- Must know how to formulate own competences related to PBL, incl. digital competences

SKILLS

- Must be able to analyse a problem and suggest a solution that uses relevant theories and methods from collaborative robotics
- Must be able to analyse a collaborative robotic system and identify relevant constraints and assessment criteria
- Must be able to synthesize, i.e., design and implement, a system (or parts hereof) using relevant theories and methods from collaborative robotics
- Must be able to evaluate a collaborative robotic system (or parts hereof) with respect to the aforementioned assessment criteria
- Can reflect over own use of PBL methods and how these methods can be used in the future projects and work situations

COMPETENCES

- Must be able to communicate the above knowledge and skills (using proper terminology) both orally and in a written report
- Must be able to select relevant collaborative robotic theories, methods, and tools, and synthesize them in a new context to produce new knowledge and solutions

TYPE OF INSTRUCTION

Project work.

EXAM

EXAMS

Name of exam	Collaborative Robotics
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	Samarbejdende robotter
Module code	ESNROBK2P4
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	Madsen

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Robotics)
Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	The Technical Faculty of IT and Design

OBJECT MANIPULATION AND TASK PLANNING

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Objective:

A robotic system may manipulate objects in its environment in order to carry out a given task. This course will go into details with methods for modelling, planning and control of such tasks. This include robots collaborating. A special focus will be on force-torque and impedance control. The course will also present methods for automatic planning of sequences of elementary operations to enable the robot to achieve higher level task goals.

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge of principles for decomposing robotic tasks into elementary operations
- Must have knowledge of methods for force-torque and impedance control
- Must have knowledge of methods for modelling of object manipulation activities for feedforward control
- Must have knowledge of principles for planning robotic tasks based on elementary operations
- Must have knowledge of task-driven automatic offline programming

SKILLS

- Must be able to design basic force-torque and impedance control systems
- Must be able to represent a task as a composition of elementary operations using formal methods
- Must be able to realize systems for automatic task planning

COMPETENCES

- Must be able to model and control object manipulation activities
- Must be able to select relevant methods and tools for task decomposition and planning and synthesize them into a system for automatic task execution

TYPE OF INSTRUCTION

See the general description of the types of instruction described in § 17.

EXAM

EXAMS

Name of exam	Object Manipulation and Task Planning
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	Planlægning og udførelse af opgaver
Module code	M-ESNROBK2K1
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	Madsen

ORGANISATION

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

HUMAN ROBOT INTERACTION

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Objective:

The interaction between human and robot is critical for successful collaborative robotics. This course focuses on understanding the fundamentals of human perception, interaction behavior and how to apply this together with technology to successfully solve tasks in collaborative robotics.

LEARNING OBJECTIVES

KNOWLEDGE

- Must be able to describe the human perceptual system
- Must be able to describe basic social communication aspects like proxemics, turn-taking, etc.
- Must be able to describe how the interaction between robot and human is influenced by design aspects such as the degree of autonomy, the design of social perception, embodiment, and input/output modalities
- Must have an overview over different types of human-robotic interfaces
- Must be able to describe potential safety issues in collaborative robotics

SKILLS

- Must be able to analyze collaborative situations and design and implement human-robot interaction based on this analysis
- Must be able to define success criteria for human robot interaction in a given context
- Must be able to evaluate systems of interacting robots and humans
- Must be able to perform usability studies

COMPETENCES

- Must be able to demonstrate an understanding of and critically discuss the need to consider technical, personal, safety, ethical, and societal demands and requirements within the area human-robot interaction
- Must be able to select relevant human-robot-interaction theories, methods, and tools, and synthesize them into an appropriate solution for a given problem

TYPE OF INSTRUCTION

See the general description of the types of instruction described in § 17.

EXAM

EXAMS

Name of exam	Human Robot Interaction
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	Menneske-robot interaktion
Module code	SOTROBK2K2
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	Dosen

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Robotics)
Study Board	Study Board of Health and Technology
Department	Department of Health Science and Technology
Faculty	The Faculty of Medicine

HUMAN BIONICS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Objective:

Controllable bio-mechanical devices added to or merge with the human body have the potential to enhance and enrich the everyday life of people. This course focuses on understanding how such systems can be designed, implemented and evaluated. The student will be equipped with knowledge and skills within bionics focusing on human assistive and rehabilitative robotics.

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about bionics and the human neural system
- Must have knowledge about human sensory motor control of movement
- Must have knowledge about invasive and non-invasive human-machine interfacing
- Must have knowledge about neural interfaces
- Must have knowledge of neural integration with external devices, e.g., prosthetics
- Must have an understanding of biologic robotic control
- Must have knowledge about robotic empowerment, e.g., exoskeleton systems, prostheses, assistive robots and their control

SKILLS

- Must be able to apply and understand human-robot interfacing methods and advanced biomechanics
- Must be able to to process biological signals for robotic control
- Must be able to close the control loop in systems within human bionics
- Must be able to apply biological signals in control of prostheses and assistive robotics

COMPETENCES

- Must be able to select relevant theories, methods, and tools, to design new solutions

TYPE OF INSTRUCTION

See the general description of the types of instruction described in § 17.

EXAM

EXAMS

Name of exam	Human Bionics
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	Menneskelig bionics
Module code	SOTROBK2K3
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	Dosen

ORGANISATION

Study Board	Study Board of Health and Technology
Department	Department of Health Science and Technology
Faculty	The Faculty of Medicine

CONTEXTUAL ROBOTICS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Objective:

An advanced robotic system will always be integrated into a particular context. The focus of this semester is to expose the students to different contexts and hereby encourage a more holistic mindset. This project will teach the student to select relevant state-of-the-art methods from the field of contextual robotics and synthesize them in a new context to produce new knowledge and solutions.

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about the terminology within contextual robotics
- Must be able to understand the notion of innovation and how it relates to contextual robotics

SKILLS

- Must have a solid overview over research within selected subfields of contextual robotics and be able to critically analyze the subfield
- Must be able to analyze a problem and (if possible) suggest a solution that uses relevant theories and methods from contextual robotics
- Must be able to analyze a contextual robotic system and identify relevant constraints and assessment criteria
- Must be able to evaluate a contextual robotic system (or parts hereof) with respect to the aforementioned assessment criteria

COMPETENCES

- Must be able to communicate the above knowledge and skills (using proper terminology) both orally and in a written report
- Must be able to select relevant state-of-the-art methods from the field of contextual robotics and synthesize them in a new context to produce new knowledge and solutions
- Be able to independently define and analyse scientific and engineering problems in the area defined by the project theme, also in cooperation with external/internal partners or as part of a multidisciplinary projects
- Be able to control the working and development process within the project theme

TYPE OF INSTRUCTION

Project work.

EXAM

EXAMS

Name of exam	Contextual Robotics
Type of exam	Oral exam based on a project
ECTS	20
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	Kontekstuelle robotter
Module code	ESNROBK3P5
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	Madsen

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Robotics)
Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	The Technical Faculty of IT and Design

ENTREPRENEURIAL PRACTICE

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Objective:

This project will teach students to develop entrepreneurial practice and develop conceptual solution by combining innovation and/or entrepreneurship theories with empirical insight.

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge of processes, methods, tools, and associated resources needed for people and companies to become and stay innovative with an emphasis on incubation processes
- Must apply specific tools and methods for supporting entrepreneurial processes
- Must apply theories of creative methodologies and creative mind-set

SKILLS

- Must be able to use sound research methods to identify and analyse a need or problem using various theoretical perspectives related to business development processes with an emphasis on incubation processes
- Must be able to experiment with possible conceptual solutions or development in order to develop new business
- Must be able to facilitate creative processes and excel in communication of a business idea

COMPETENCES

- Must be able to approach the field of robotics using scientifically sound methods and informed by experiment with conceptual solutions in relation to market/users, technology, organization, and resource
- Must be able to contribute to creative further development of a conceptual solution by combining innovation and/or entrepreneurship theories with empirical insight
- Must be able to critically evaluate own analysis and solutions
- Be able to independently define and analyse scientific and engineering problems in the area defined by the project theme, also in cooperation with external/internal partners or as part of multidisplinary projects
- Be able to control the working and development process within the project theme

TYPE OF INSTRUCTION

Project work

EXAM

EXAMS

Name of exam	Entrepreneurial Practice
Type of exam	Oral exam based on a project
ECTS	20
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	Praktisk entreprenørskab
Module code	ESNROBK3P6
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	Madsen

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Robotics)
Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	The Technical Faculty of IT and Design

PROJECT-ORIENTED STUDY IN AN EXTERNAL ORGANISATION

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Has knowledge about the organization of the company and business procedures and policies
- Has knowledge about performance measures in the company
- Has developed a fundamental business sense
- Has knowledge of the competence profile of the program and how the academic internship contributes to the competence profile
- Has gained deepened knowledge into engineering theories and methods within the programme

SKILLS

- Can initiate and ensure the completion of an agreement for the academic internship, with learning objectives corresponding to the semester at the master's program
- Can apply analytic, methodological and/or theoretic skills to address advanced engineering problems in an industrial context
- Can contribute in a professional manner to company objectives as an individual and in teams in accordance with the project management model applied in the company
- Can collaborate and communicate with peers, managers and others
- Can document the academic internship in a report and defend it orally

COMPETENCES

- Can discuss and reflect upon the learning outcomes of the academic internship.
- Can discuss the need for knowledge transfer between academia and industry.
- Has a deepened understanding of the academic interests to pursue in the master's thesis and possible job positions to aim at after graduation

TYPE OF INSTRUCTION

Project work

EXAM

EXAMS

Name of exam	Project-Oriented Study in an External Organisation
Type of exam	Oral exam based on a project
ECTS	30
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	Projektorienteret forløb i en virksomhed
Module code	ESNROBK3P3
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	Madsen

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Robotics)
Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	The Technical Faculty of IT and Design

PROJECT-ORIENTED STUDY IN AN EXTERNAL ORGANISATION

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Has knowledge about the organization of the company and business procedures and policies
- Has knowledge about performance measures in the company
- Has developed a fundamental business sense
- Has knowledge of the competence profile of the program and how the academic internship contributes to the competence profile
- Has gained deepened knowledge into engineering theories and methods within the programme

SKILLS

- Can initiate and ensure the completion of an agreement for the academic internship, with learning objectives corresponding to the semester at the master's program
- Can apply analytic, methodological and/or theoretic skills to address advanced engineering problems in an industrial context
- Can contribute in a professional manner to company objectives as an individual and in teams in accordance with the project management model applied in the company
- Can collaborate and communicate with peers, managers and others
- Can document the academic internship in a report and defend it orally

COMPETENCES

- Can discuss and reflect upon the learning outcomes of the academic internship.
- Can discuss the need for knowledge transfer between academia and industry.
- Has a deepened understanding of the academic interests to pursue in the master's thesis and possible job positions to aim at after graduation

TYPE OF INSTRUCTION

Project work

EXAM

EXAMS

Name of exam	Project-Oriented Study in an External Organisation
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	Projektorienteret forløb i en virksomhed
Module code	ESNROBK3P7
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	Madsen

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Robotics)
Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	The Technical Faculty of IT and Design

MASTER'S THESIS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The master's thesis can be conducted as a long master's thesis. If choosing to do a long master's 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.

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge, at the highest international level of research, of at least one of the core fields of the education
- Have comprehension of implications of research (research ethics).

SKILLS

- Can reflect upon the scientific basis on their knowledge.
- Can argue for the relevance of the chosen problem to the education, including giving a specific account for the core of the problem and the technical context in which it appears
- Can account for possible methods with which to solve the formulated problem of the project, describe and assess the applicability of the chosen method(s), and account for any delimitations made and the way these will influence on the results of the product
- Can analyse and describe the chosen problem applying relevant theories, methods and experimental data
- Can describe the relevant theories and methods in a way that highlights the characteristics and hereby document knowledge of the applied theories, methods, possibilities and delimitations within the relevant problem area
- Can analyse and assess experimental data, including the effect the assessment method has on the validity of the results.

COMPETENCES

- Can communicate scientific problems in writing and orally, incl. using digital tools, to specialist and non-specialist
- Can dissect and manage situations that are complex, unpredictable and which require new solutions
- Can independently initiate and perform collaboration within the discipline and interdisciplinary as well, and is able to take professional responsibility
- Can independently take responsibility for his or her own professional development and specialization, getting knowledge from different platforms, incl. digital platforms

TYPE OF INSTRUCTION

Project work individual or in groups of 2-3 persons

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	ESNROBK4P4
Module type	Project
Duration	2 semesters
Semester	Spring
ECTS	50
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Madsen

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Robotics)
Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	The Technical Faculty of IT and Design

MASTER'S THESIS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Have knowledge, at the highest international level of research, of at least one of the core fields of the education
- Have comprehension of implications of research (research ethics).

SKILLS

- Can reflect upon the scientific basis on their knowledge.
- Can argue for the relevance of the chosen problem to the education, including giving a specific account for the core of the problem and the technical context in which it appears
- Can account for possible methods with which to solve the formulated problem of the project, describe and assess the applicability of the chosen method(s), and account for any delimitations made and the way these will influence on the results of the product
- Can analyse and describe the chosen problem applying relevant theories, methods and experimental data
- Can describe the relevant theories and methods in a way that highlights the characteristics and hereby document knowledge of the applied theories, methods, possibilities and delimitations within the relevant problem area
- Can analyse and assess experimental data, including the effect the assessment method has on the validity of the results.

COMPETENCES

- Can communicate scientific problems in writing and orally, incl. using digital tools, to specialist and non-specialist
- Can dissect and manage situations that are complex, unpredictable and which require new solutions
- Can independently initiate and perform collaboration within the discipline and interdisciplinary as well, and is able to take professional responsibility
- Can independently take responsibility for his or her own professional development and specialization, getting knowledge from different platforms, incl. digital platforms

TYPE OF INSTRUCTION

Project work individual or in groups of 2-3 persons

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	ESNROBK4P3
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	30
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Madsen

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Robotics)
Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	The Technical Faculty of IT and Design

READINGS IN ROBOTICS

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Objective:

The goal of this course is to provide the foundations necessary to perform research within the field of robotics. The course takes a practical approach and focuses on the craftsmanship needed as a scientist. Students explore state of the art theories and techniques in a formalized manner by analyzing a selection of research texts fundamental to robotics through, e.g., paper presentation, reproduction of experiments, etc.

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about how to perform a state-of-art analysis
- Must have knowledge about the current research agenda within robotics

SKILLS

- Must be able to analyze specific research topics within robotics
- Must be able to perform critical annotation of relevant robotic literature
- Must be able to define taxonomies for relevant robotic literature

COMPETENCES

- Must be able to critically evaluate a robotic system in relation to state-of-the-art robotic research

TYPE OF INSTRUCTION

See the general description of the types of instruction described in § 17.

EXAM

EXAMS

Name of exam	Readings in Robotics
Type of exam	Active participation/continuous evaluation Re-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	Studiekreds i robotik
Module code	M-ESNROBK3K1

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	Madsen

ORGANISATION

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

INNOVATION AND ENTREPRENEURSHIP

2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Objective:

Robotics is a subject area characterized by a high level of innovation and entrepreneurship. This course will teach students the basics of innovation-based entrepreneurial processes, business modelling, and enable them to make a business case for a start-up.

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge of innovation-based entrepreneurial processes, including theories, methods and tools related to the generic innovation sub-processes discovery, incubation and acceleration.
- Must have knowledge of the concept of problem (re)framing and the prototyping process for developing a product/service/business concept
- Must have knowledge about business modeling, intellectual property and startups
- Must have knowledge of the role and impact of corporate entrepreneurship/(radical) innovation in organisations

SKILLS

- Must be able to make use of the theories and methods in entrepreneurial cases/project
- Must be able to collect, use and transform data on user/customer behavior in framing, specification and prototyping.
- Must be able to evaluate theoretic and practical needs for the development of a business/business area
- Must be able to make a business case for a new business area/startup

COMPETENCES

- Must be able to select and use various relevant theoretical perspectives, methods and tools in relation to the planning and engaging in entrepreneurial business development processes
- Must be able to plan and execute a prototyping process that involves users, customers and other relevant stakeholders
- Must be able to contribute constructively and professionally in multidisciplinary innovation/entrepreneurship ventures
- Must able to evaluate the business case, including funding issues.
- Critically evaluate own analysis and solutions

TYPE OF INSTRUCTION

See the general description of the types of instruction described in § 17.

EXAM

EXAMS

Name of exam	Innovation and Entrepreneurship
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	Innovation og entreprenørskab
Module code	M-ESNROBK3K2
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	Madsen

ORGANISATION

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

MACHINE LEARNING

2024/2025

RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on basic knowledge in probability theory, statistics, and linear algebra

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The course gives a comprehensive introduction to machine learning, covering learning theory, methods and applications. The objective is realized by presenting methods and tools proven valuable and by addressing specific application problems.

LEARNING OBJECTIVES

KNOWLEDGE

Students must have knowledge about:

- Supervised learning methods including logistic regression, support vector machines, and decision trees.
- Unsupervised learning methods including K-means, Gaussian mixture model, and EM algorithm.
- Feed-forward, convolutional and recurrent neural networks, transfer learning.
- Probabilistic graphical models, hidden Markov models.
- Reinforcement learning.
- Bayesian decision theory, bias and variance trade-off and cross-validation.

SKILLS

- Must be able to apply the taught methods to solve concrete engineering problems.
- Must be able to evaluate and compare the methods within a specific application problem.

COMPETENCES

- Must have competences in analyzing a given problem and identifying appropriate machine learning methods to the problem.
- Must have competences in understanding the strengths and weaknesses of the methods.

TYPE OF INSTRUCTION

The course will be taught a combination of lectures, demos of applications, exercises and mini-project

EXAM

EXAMS

Name of exam	Machine Learning
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	Maskinlæring
Module code	ESNESK1K6
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	Madsen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	The Technical Faculty of IT and Design

QUANTUM INFORMATION AND COMPUTING

2024/2025

RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on basic knowledge of linear algebra and probability theory. More advanced topics from the above topics will be introduced during the course.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Quantum technology is among the most anticipated new technologies of the 21st century. In particular, large-scale quantum computers have the possibility of providing exponential speedups in various kinds of computations. During the last decade, small-scale quantum computers have emerged, with companies like IBM, Google and Microsoft as the frontrunners. The fundamental computational building block in quantum computing is the qubit. While millions of qubits are needed to outperform classical supercomputers, current state-of-the-art quantum computers only have hundreds of qubits available. However, with the rapid development in the field, we can expect this number to grow in the coming years and decades.

In other words, a quantum computer is no longer a dream and far-fetched future; it will be an accessible computing tool for computer scientists and engineers in the coming years. Therefore, the course will introduce the participants to the main concepts of quantum computing.

The course will cover the subject of postulates of quantum mechanics, quantum circuits, quantum algorithms and their complexity. Special attention will be paid to currently available "noisy" quantum computers consisting of a few qubits - so-called NISQ (noisy intermediate-scale quantum) computers.

The students will, through exercises, get hands-on experience with analyzing and implementing quantum algorithms on state-of-the-art quantum hardware.

LEARNING OBJECTIVES

KNOWLEDGE

Students must have knowledge about:

- The postulates of quantum mechanics, including superposition, measurements and entanglement.
- State vector and density operator formalism for describing quantum states.
- Basic quantum gates and quantum circuits, including single-qubit gates such as Pauli and Hadamard gates, and multi-qubit gates such as CNOT, SWAP, Toffoli, etc.
- Quantum communication protocols, including quantum teleportation, superdense coding, quantum key distribution.
- Elements of complexity theory, including complexity classes for quantum computing.
- Basic quantum algorithms, including Deutsch-Jozsa algorithm, quantum Fourier transform, Shor’s factoring algorithm, Grover’s search algorithm.
- Different forms of quantum noise and basic quantum error correction codes.
- Noisy Intermediate-Scale Quantum (NISQ) devices and basic NISQ algorithms, including variational quantum algorithms and quantum neural networks.

SKILLS

- Must be able to analyze basic quantum circuits, quantum communication protocols and quantum algorithms.
- Must be able to discuss noise in quantum computing and the need for error correction.
- Must be able to formulate elementary problems within optimization and machine learning to be suitable for NISQ devices.

COMPETENCES

- Must have competences in understanding the strengths and weaknesses of quantum computing versus classical computing.
- Must be able to implement and simulate basic quantum algorithms on classical computers.

- Must be able to implement small-scale quantum algorithms on quantum hardware, e.g., through available cloud services.

TYPE OF INSTRUCTION

The course will be taught a combination of lectures, demos of applications, exercises and mini-project.

EXAM

EXAMS

Name of exam	Quantum Information and Computing
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	Kvanteinformation og kvantecomputer
Module code	ESNESNK1K1
Module type	Course
Duration	1 semester
Semester	Autumn and Spring
ECTS	5
Language of instruction	English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Madsen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	The Technical Faculty of IT and Design

MODELLING OF PHYSICAL SYSTEMS

2024/2025

RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on basic knowledge of Newronian mechanics

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The purpose of this course is to give the student advanced competences within the realm of modelling of physical systems. The course will cover various aspects within mechanical systems, electro-mechanical systems and thermodynamically systems. Students who complete the course will be able to model and design various real-world systems.

LEARNING OBJECTIVES

KNOWLEDGE

The student should have knowledge about:

- Static and dynamic friction models
- Rigid body kinematics and dynamics
- Analytical mechanics
- Electromechanical energy conversion
- Fundamental laws of thermodynamics
- Kinematics of flow
- Mass, momentum and energy balance
- Gas or compressor dynamics

SKILLS

- Should be able to formulate models of basic mechanical, electromechanical, and thermodynamic systems.
- Should be able to identify correct modelling methods for basic engineering problem within mechanical, electromechanical, and thermodynamic systems.
- Should be able to identify limitations and application area of physical systems

COMPETENCES

- Capable of modeling a physical system with sufficient information level, suitable for solving a given engineering problem
- Capable of applying relevant software tools to simulate physical systems

TYPE OF INSTRUCTION

As described in §17

EXAM

EXAMS

Name of exam	Modelling of Physical Systems
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	Modellering af fysiske systemer
Module code	ESNESK1K4
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	Madsen

ORGANISATION

Education owner	Master of Science (MSc) in Engineering (Electronic Systems)
Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	The Technical Faculty of IT and Design

NON-LINEAR CONTROL AND MULTI-BODY SYSTEMS 2024/2025

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

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

SKILLS

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

COMPETENCES

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

TYPE OF INSTRUCTION

The programme is based on a combination of academic, problem oriented and interdisciplinary approaches and organised based on the following types of instruction that combine skills and reflection: - lectures - class teaching - project work - workshops - exercises (individually and in groups) - teacher feedback - professional reflection - portfolio work - laboratory Work The form(s) of teaching will be determined and described in connection with the planning of the semester. The description will account for the form(s) of teaching and may be accompanied by an elaboration of the roles of the participants.

EXTENT AND EXPECTED WORKLOAD

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

EXAM

EXAMS

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

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

ADDITIONAL INFORMATION

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

FACTS ABOUT THE MODULE

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

ORGANISATION

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