AALBORG UNIVERSITET

# STUDIEORDNING FOR KANDIDATUDDANNELSEN I COMPUTERTEKNOLOGI, 2022

CIVILINGENIØR
AALBORG

MODULER SOM INDGÅR I STUDIEORDNINGEN

# INDHOLDSFORTEGNELSE

# COMMUNICATION SYSTEMS

# 2024/2025

## CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

### LEARNING OBJECTIVES

#### KNOWLEDGE

Must have knowledge about:

- The impact of various factors on behavior of communication protocols and the associated tradeoffs
- Network protocols operating on different layers of OSI model
- At least one of the following aspects: distribution, storage, performance, safety, real-time provision
- Organization of a scientific publication and scientific communication process

#### SKILLS

Must be able to:

- Design, implement and analyze a solution to a practically occurring problem in a communication network , focusing on one of the following aspects: distribution, storage, performance, safety, real-time provision
- Perform suitable test of the implemented solution and make performance evaluation of the solution by selecting the proper evaluation metrics
- Can write a paper for a scientific conference/ journal and prepare an oral presentation of a paper

#### COMPETENCES

- Make a basic design, implementation and performance evaluation of a problem involving a communication network
- Formulate and explain scientific hypotheses and results achieved through scientific work
- Work according to a scientific method and present results in the form of a scientific article and at a seminar/scientific conference
- Read and understand selected scientific literature and next apply the theories, methods, and/or tools in order to solve a selected problem , as well as judge and prioritize the validity of various of scientific information

### TYPE OF INSTRUCTION

Types of instruction are listed in §17; Structure and contents of the programme.

## EXAM

### EXAMS

| | |
|---|---|
| Name of exam | Communication Systems |
| Type of exam | Oral exam based on a project |
| ECTS | 15 |
| Assessment | 7-point grading scale |
| Type of grading | Internal examination |
| Criteria of assessment | The criteria of assessment are stated in the Examination Policies and Procedures |

## FACTS ABOUT THE MODULE

| | |
|---|---|
| Danish title | Kommunikationssystemer |
| Module code | ESNNDSK1P2 |
| 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 (Computer Engineering) |
| Study Board | Study Board of Electronics and IT |
| Department | Department of Electronic Systems |
| Faculty | The Technical Faculty of IT and Design |

# 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

### PREREQUISITE FOR ENROLLMENT FOR THE EXAM

- Submission of mini-project report

### 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 | ESNESK1K1 |
| 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 |

# DEPENDABLE AND SECURE DISTRIBUTED SYSTEMS 2024/2025

## CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

### LEARNING OBJECTIVES

#### KNOWLEDGE

The students must have insight in:

- Different types of faults (accidental and malicious) that can occur during the operation phase of a communication system
- Dependability concepts
- Methods for fault detection and fault recovery
- Cryptographic protocols and cryptographic distributed algorithms
- Anomaly detection in cyber-physical systems
- Distributed ledger technologies

#### SKILLS

Students must be able to:

- list the different considered faults, both accidental and malicious, how they propagate through the system and assess their severity and occurrence likelihood
- quantitatively assess the impact of faults on system availability and system reliability
- apply methods for fault-detection and recovery to complex networked systems, including cyber-physical systems
- Develop fault tolerant strategies for ensuring the continuation of the system in the presence of faults
- incorporate cryptographic algorithms into protocol design to achieve secure network operation
- use Machine learning tools and stochastic models for anomaly detection in networks

#### COMPETENCES

Students must be able to

- Select fault-tolerant and security-provision strategies for a given distributed system.
- systematically analyze distributed, networked systems and feedback the analysis results into an efficient, fault-tolerant and secure system and protocol design

### TYPE OF INSTRUCTION

As descript in §17

## EXAM

### EXAMS

| | |
|---|---|
| Name of exam | Dependable and Secure Distributed 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 | Pålidelighed og sikker distribuerende systemer |
| Module code | ESNNDSK2K4 |
| 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 (Computer Engineering) |
| Study Board | Study Board of Electronics and IT |
| Department | Department of Electronic Systems |
| Faculty | The Technical Faculty of IT and Design |

# PERFORMANCE AND RELIABILITY ANALYSIS OF COMMUNICATION NETWORKS

# 2024/2025

## CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

### LEARNING OBJECTIVES

#### KNOWLEDGE

The students must have insight in:

- Layering architecture and impact of lower layers on higher layers performance
- Cellular networks, including cellular architectures, frequency reuse and resource management
- Reliability concepts and analysis
- Traffic modelling including heavy tailored behavior
- Queueing models
- Information theory
- Discrete event simulation

#### SKILLS

The students must be able to

- having understanding of different network architectures
- Apply probabilistic models to reliability analysis of a distributed system
- apply simple and advanced traffic and queuing models, in performance analysis of real-life traffic systems
- Develop a discrete event simulator for performance assessment of a distributed system

#### COMPETENCES

The students must be able to:

- select the appropriate reliability, queuing and traffic models to be used in the modeling of a specific system, analyse them and apply
- design an abstract communication system chain and protocol stack, and justify the design choices in relation to the intended use case

### TYPE OF INSTRUCTION

As described in §17

## EXAM

### EXAMS

| | |
|---|---|
| Name of exam | Performance and Reliability Analysis of Communication Networks |
| 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 | Ydeevne og pålidelighedsanalyse af kommunikationsnetværk |
| Module code | ESNNDSK1K3 |
| 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 |

# RELIABILITY, SAFETY AND SECURITY

# 2024/2025

## CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

### LEARNING OBJECTIVES

#### KNOWLEDGE

Must have knowledge about:

- Techniques for increasing the resilience towards accidental and/ or malicious errors in the considered type of a distributed system
- Methods and tools to achieve fault tolerant, secure and efficient operation of a distributed system.
- Protocol design to support distributed mode of operation in a communication network. Data access and data delivery in a scalable manner. Data management issues in complex networks
- how to formulate own competences related to PBL, incl. digital competences

#### SKILLS

Must be able to:

- conduct synthesis of theories, methods and techniques used for at least one of the following: robust communication; distribution, storage and processing of data in a distributed system; secure communication
- Design protocols and algorithms that are able to support e.g. disruption tolerant networking, multi-hop communication in sensor networks, embedded systems, real-time and multimedia systems, content distribution networks, peer-to-peer systems, large scale distributed systems, storage and file systems, autonomic computing, network security.
- reflect over own use of PBL methods and how these methods can be used in future projects and work situations.

#### COMPETENCES

- undertake the construction of a well-functioning distributed and/or communication system yielding high performance and efficiency or satisfying reliability requirements.
- Communicate the project work in sound scientific and academic form

### TYPE OF INSTRUCTION

As descript in §17

## EXAM

### EXAMS

| | |
|---|---|
| Name of exam | Reliability, Safety and Security |
| 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 | Pålidelighed og sikkerhed |
| Module code | ESNNDSK2P2 |
| 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 (Computer Engineering) |
| Study Board | Study Board of Electronics and IT |
| Department | Department of Electronic Systems |
| Faculty | The Technical Faculty of IT and Design |

# ADVANCED NETWORK SECURITY

# 2024/2025

## CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

### LEARNING OBJECTIVES

#### KNOWLEDGE

The students must have knowledge about:

- Cybercrime and different kinds of cyberattacks, including the underlying motivations and techniques.
- Different malware types
- systems for detecting, establishing and preventing intrusions (intrusion detection systems and intrusion prevention systems) - including knowledge about relevant monitoring and logging
- Traffic monitoring and analysis
- Using machine learning techniques for intrusion detection

#### SKILLS

Students must be able to:

- Methods for network-based prevention, detection and analysis of network-based cyber-attacks, including analysis of traffic at different layers of the TCP/IP protocol stack.
- configuration and operation of secure test environments.
- applying selected tools for attacking and defending network devices and network infrastructure, including detection and establishing of attacks.

#### COMPETENCES

The students must be able to

- Evaluate which methods and tools for detecting, preventing and analyzing network-based attacks should be used for a specific case/problem

### TYPE OF INSTRUCTION

As descript in §17

## EXAM

### EXAMS

| | |
|---|---|
| Name of exam | Advanced Network Security |
| 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 netværkssikkerhed |
| Module code | ESNNDSK1K2 |
| 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 (Computer Engineering) |
| Study Board | Study Board of Electronics and IT |
| Department | Department of Electronic Systems |
| Faculty | The Technical Faculty of IT and Design |

# AI IN THE CONTEXT OF COMPUTER ENGINEERING

# 2024/2025

## CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

### LEARNING OBJECTIVES

#### KNOWLEDGE

The student should have knowledge about:

- How different Artificial Intelligence methods, incl Machine Learning, can be used to solve a concrete problem within the field of Computer Engineering
- Specific in-depth knowledge about at least one advanced method or technology applied in the field of Computer engineering, such as modelling and performance analysis of networks and distributed systems; computer vision; sound technology.

#### SKILLS

- Can explain the process of and criteria for choosing an approach within the AI toolbox to solve a concrete problem within the field of Computer Engineering
- Can identify a suitable method and apply it to solve a concrete problem within the field of Computer Engineering
- Can analyse the performance and discuss the results, advantages and disadvantages of the chosen AI method

#### COMPETENCES

- Must be able to analyze a selected problem within Computer Engineering field and apply one of the methods from AI toolbox to produce a new knowledge and/or solution

### TYPE OF INSTRUCTION

As descript in §17

## EXAM

### EXAMS

| | |
|---|---|
| Name of exam | AI in the Context of Computer Engineering |
| 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 | AI i konteksten af computerteknologi |
| Module code | ESNNDSK3P8 |
| 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 (Computer Engineering) |
| 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

The student stays in a company with the purpose of learning and applying theories and methods to address engineering problems in an industrial context. In addition, the student will be introduced to business procedures and policies.

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

### LEARNING OBJECTIVES

#### KNOWLEDGE

- Have knowledge about the organization of the company, its business procedures, policies and performance measures
- Have knowledge of the competence profile of the program and how the project oriented study in an external organization contributes to the competence profile
- Have knowledge about engineering theories and methods relevant to product innovation
- Details of an engineering problem related to an industrial context

#### SKILLS

- Can apply analytic, methodological and/or theoretic skills to address an advanced engineering problems in the context of product innovation
- 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, and document the outcome of the project-oriented study in writing

#### COMPETENCES

- Can discuss and reflect on the learning outcomes of the project-oriented study in an external organization
- Have deepened understanding of product innovation and how knowledge transfer between academia and industry contributes to this
- Able to analyze and document a solution related to product innovation

### TYPE OF INSTRUCTION

As described in §17

## EXAM

### EXAMS

| | |
|---|---|
| Name of exam | Project-Oriented Study in an External Organisation |
| 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 | Projektorienteret forløb i en virksomhed |
| Module code | ESNNDSK3P5 |
| 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 (Computer Engineering) |
| 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

The student stays in a company with the purpose of learning and applying theories and methods to address engineering problems in an industrial context. In addition, the student will be introduced to business procedures and policies.

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

### LEARNING OBJECTIVES

#### KNOWLEDGE

- Have knowledge about the organization of the company, its business procedures, policies and performance measures
- Have knowledge of the competence profile of the program and how the project oriented study in an external organization contributes to the competence profile
- Have knowledge about engineering theories and methods relevant to product innovation
- Details of an engineering problem related to an industrial context

#### SKILLS

- Can apply analytic, methodological and/or theoretic skills to address an advanced engineering problems in the context of product innovation
- 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, and document the outcome of the project-oriented study in writing

#### COMPETENCES

- Can discuss and reflect on the learning outcomes of the project-oriented study in an external organization
- Have deepened understanding of product innovation and how knowledge transfer between academia and industry contributes to this
- Able to analyze and document a solution related to product innovation

### TYPE OF INSTRUCTION

As described in §17

## EXAM

### EXAMS

| | |
|---|---|
| Name of exam | Project-Oriented Study in an External Organisation |
| Type of exam | Oral exam based on a project |
| ECTS | 25 |
| 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 | ESNNDSK3P6 |
| 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 (Computer Engineering) |
| 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

The student stays in a company with the purpose of learning and applying theories and methods to address engineering problems in an industrial context. In addition, the student will be introduced to business procedures and policies.

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

### LEARNING OBJECTIVES

#### KNOWLEDGE

- Have knowledge about the organization of the company, its business procedures, policies and performance measures
- Have knowledge of the competence profile of the program and how the project oriented study in an external organization contributes to the competence profile
- Have knowledge about engineering theories and methods relevant to product innovation
- Details of an engineering problem related to an industrial context

#### SKILLS

- Can apply analytic, methodological and/or theoretic skills to address an advanced engineering problems in the context of product innovation
- 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, and document the outcome of the project-oriented study in writing

#### COMPETENCES

- Can discuss and reflect on the learning outcomes of the project-oriented study in an external organization
- Have deepened understanding of product innovation and how knowledge transfer between academia and industry contributes to this
- Able to analyze and document a solution related to product innovation

### TYPE OF INSTRUCTION

As described in §17

## 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 | ESNNDSK3P7 |
| Module type | Project |
| Duration | 1 semester |
| Semester | Autumn |
| ECTS | 30 |
| Language of instruction | English |
| Empty-place Scheme | Yes |
| Location of the lecture | Campus Aalborg, Campus Copenhagen |
| Responsible for the module | Madsen |

## ORGANISATION

| | |
|---|---|
| Education owner | Master of Science (MSc) in Engineering (Computer Engineering) |
| 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 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.

### LEARNING OBJECTIVES

#### KNOWLEDGE

- Have knowledge at the highest international level of research in a selected area of the field of Computer Engineering
- have comprehension of research ethics

#### SKILLS

- can argue for the relevance of the chosen problem and the technical connections in which it appears
- can account for the scientific basis of the problem and possible methods to solve it, including delimitation of the problem and the applicability and impact of the chosen method to the solution
- can analyze and describe the chosen problem applying relevant theories, methods and experimental data

#### COMPETENCES

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

### TYPE OF INSTRUCTION

As described in §17

## 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 | ESNNDSK4P6 |
| Module type | Project |
| Duration | 2 semesters |
| Semester | Autumn |
| ECTS | 50 |
| Language of instruction | English |
| Empty-place Scheme | Yes |
| Location of the lecture | Campus Aalborg, Campus Copenhagen |
| Responsible for the module | Madsen |

## ORGANISATION

| | |
|---|---|
| Education owner | Master of Science (MSc) in Engineering (Computer Engineering) |
| 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 in a selected area of the field of Computer Engineering
- have comprehension of research ethics

#### SKILLS

- can argue for the relevance of the chosen problem and the technical connections in which it appears
- can account for the scientific basis of the problem and possible methods to solve it, including delimitation of the problem and the applicability and impact of the chosen method to the solution
- can analyze and describe the chosen problem applying relevant theories, methods and experimental data

#### COMPETENCES

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

### TYPE OF INSTRUCTION

As described in §17

## 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 | ESNNDSK4P5 |
| Module type | Project |

| | |
|---|---|
| Duration | 1 semester |
| Semester | Spring |
| ECTS | 30 |
| Language of instruction | English |
| Empty-place Scheme | Yes |
| Location of the lecture | Campus Aalborg, Campus Copenhagen |
| Responsible for the module | Madsen |

## ORGANISATION

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

# DEEP LEARNING

# 2024/2025

## RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

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

## CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

This course introduces deep learning both by presenting valuable methods and by addressing specific applications. This course covers both theory and practices for deep learning. The students will also have hands-on exercises experimenting with a variety of deep learning architectures for applications.

### LEARNING OBJECTIVES

#### KNOWLEDGE

Students must have knowledge about:

- models and representation learning
- Advanced topics including attention and transformer networks, autoencoders, generative adversarial networks, adversarial attacks, self-supervised learning, and deep reinforcement learning
- Regularization, optimization, hyperparameter tuning, and data augmentation
- Bias, fairness, and explainable AI
- Design and implementation of deep learning for selected applications

#### SKILLS

- Must be able to apply the taught methods to solve real-world 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 deep learning methods to the problem.
- Must have competences in understanding the strengths and weaknesses of the methods.

### TYPE OF INSTRUCTION

As descript in §17

## EXAM

### PREREQUISITE FOR ENROLLMENT FOR THE EXAM

- Submission of mini-project report

### EXAMS

| | |
|---|---|
| Name of exam | Deep 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 | Dyb læring |
| Module code | ESNNDSK2K3 |
| 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

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

# NUMERICAL SCIENTIFIC COMPUTING

# 2024/2025

## CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

### LEARNING OBJECTIVES

#### KNOWLEDGE

- Must have knowledge about the possible sppedup by using parallelization (Amdahls law / Gustafson-Barsis' law) under different conditions
- Must have knowledge about message and data passing in distributed computing
- Must have knowledge about programming techniques, profiling, benchmarking, code optimization etc.
- Must have knowledge about numerical accuracy in scientific computing problems

#### SKILLS

- Must be able to translate the covered principles regarding scientific computing and software development to practice in the programming language(s) utilized in the course
- Must be able to implement software programs to solve scientific computational problems using parallel computing.
- Must be able to implement software programs to solve scientific computational problems using distributed computing units or high-performance specialized computing units (such as GPU)
- Must be able to debug, validate, optimize, benchmark and profile developed software modules.
- Must be able to assess the performance of different hardware architectures for scientific computing problems.

#### COMPETENCES

- Must be able to assess and weigh resources spent on software development against total subsequent computing time for concrete scientific computing problems.
- Must be able to reflect on different software development methods and independently select and combine elements thereof for use in concrete scientific computing problems.

### TYPE OF INSTRUCTION

As described in §17

## EXAM

### EXAMS

| | |
|---|---|
| Name of exam | Numerical Scientific Computing |
| Type of exam | Active participation/continuous evaluation<br>Oral reexamination |
| 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 | Numerisk videnskabelig beregning |

| | |
|---|---|
| Module code | ESNAVSK2K1 |
| 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

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

# NETWORKS AND SYSTEMS

# 2024/2025

## RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on basic knowledge of the architecture of communication systems, probability and stochastic processes/systems; knowledge about optimization and fundamental concepts in machine learning

## CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

This course gives an overview of methodologies for analyzing dynamic and distributed network coupled systems. By obtaining an understanding of the taxonomy of distributed systems, e.g. their failure mechanisms and networking protocols, the students should obtain a systematic approach to the design of the properties of the individual systems as well as their interconnecting behavior (network architectures) for optimizing overall system behavior.

Theory and practical issues in hardware and software implementations for implementing such networked systems are covered.

### LEARNING OBJECTIVES

#### KNOWLEDGE

- Must have knowledge about distributed network architectures with systems of systems and the taxonomy of fault tolerant systems, including tools for testing and verification
- Must have an understanding of network protocols for distributed dynamic systems, including such as network synchronization
- Must have an understanding of network performance evaluation, e.g. network reliability/availability, delay/round-trip time, and fault/effect) and abstracted models/tools for evaluating
- Must have knowledge about methods for implementing networked systems, e.g. based on embedded systems, edge and cloud platforms, explainable and trustworthy artificial intelligence

#### SKILLS

- Must be able to analyse and evaluate performance of practically occurring examples of networked systems
- Must be able to combine the knowledge and techniques into design principles for networked (embedded) systems

#### COMPETENCES

- Must be able to identify requirements and select an appropriate communication architecture for networked systems of systems within one of the three core topics of the program
- Must be able to identify appropriate tools, models and techniques for the analysis of complex networked systems

### TYPE OF INSTRUCTION

As descript in §17

## EXAM

### EXAMS

| | |
|---|---|
| Name of exam | Networks and 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 | Netværk og systemer |
| Module code | ESNESK2K2 |
| 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

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

# STOCHASTIC SYSTEMS

# 2024/2025

## RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on basic knowledge of statistical and probabilistic quantities (stochastic variable, mean, variance, hypothesis test, etc.)

## CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The purpose is to introduce theory, models and tools for analysis of stochastic signals and systems. Stochastic signals and systems can loosely be described as anything random that changes in time and which we formally describe by stochastic processes. They are at the core of a number of disciplines in engineering, for example wireless communication, automation and control, and speech processing. While students are familiar that signals can change due to noise, a system can behave stochastic and not always produce the same output for a given input.

Students should become familiar with the description of stochastic signals and systems and learn about relevant theoretical models to describe them and understand the stochastic properties. Based on this the students learn how to analyze and simulate such processes using computer programming language.

### LEARNING OBJECTIVES

#### KNOWLEDGE

The student should have knowledge about:

- Probability theory necessary to understand discrete time stochastic processes
- Various types of stochastic process, such as WSS, Markov, Poisson, and Gaussian
- Discrete time linear stochastic dynamical systems in transfer and state space form, including ARIMAX

#### SKILLS

- Be able to analyze and simulate stochastic processes
- Be able to apply stochastic processes in selected engineering disciplines e.g., within queuing systems, communication systems and control systems.

#### COMPETENCES

- Attain appropriate “engineering” intuition of the basic concepts and results related to stochastic processes that allow to model, analyze and design solutions to engineering problems involving stochastic signals and systems

### TYPE OF INSTRUCTION

As descript in §17

## EXAM

### EXAMS

| | |
|---|---|
| Name of exam | Stochastic 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 | Stokastiske systemer |
| Module code | ESNESK1K2 |
| 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 |

# IMAGE PROCESSING AND COMPUTER VISION

# 2024/2025

## RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The student is recommended to have basic knowledge in probability theory, statistics, and linear algebra

## CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Cameras capture visual data from the surrounding world. Building systems which can automatically process such data requires image processing and computer vision methods. Students who complete the module will understand relevant theories and methods within image processing and computer vision as well their applicability.

### LEARNING OBJECTIVES

#### KNOWLEDGE

- Must be able to understand the general framework of image processing including point- and neighborhood operations
- Must be able to explain the principles behind robust feature point algorithms
- Must have knowledge of different motion analysis principles
- Must be able to understand how to obtain 3D data via sensors, stereo vision or structure-from-motion
- Must be able to understand how deep learning can be applied to images

#### SKILLS

- Must be able to apply one or more tracking frameworks
- Must be able to apply deep learning approaches to image classification
- Must be able to apply deep learning approaches to object detection
- Must be able to apply deep learning approaches to semantic segmentation
- Must be able to apply appropriate annotation tools and evaluation metrics

#### COMPETENCES

- Must be able to analyse a specific problem and based upon this select, implement and evaluate an appropriate image processing or computer vision method
- Must have competencies in understanding the strengths and weaknesses of a method in relation to a specific problem

### TYPE OF INSTRUCTION

As described in § 17.

## EXAM

### PREREQUISITE FOR ENROLLMENT FOR THE EXAM

- Submission of mini-project report

### EXAMS

| | |
|---|---|
| Name of exam | Image Processing and Computer Vision |
| 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 | Billedbehandling og computervision |
| Module code | MSNAVSK1232 |
| 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 Copenhagen |
| Responsible for the module | Madsen |

## ORGANISATION

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

# PERCEPTION AND ACQUISITION OF DATA

# 2024/2025

## RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds upon basic knowledge in linear algebra.

## CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The course gives an introduction to human perception and how perceived signals can be used for cognition. Furthermore, the course introduces the digital version of human perception, i.e., how sensors capture signals and convert them into data. Focus is especially on sound, image and psychophysiological data.

### LEARNING OBJECTIVES

#### KNOWLEDGE

- Must have knowledge about how the brain works in terms of biology and functionality
- Must have knowledge about the human auditory system
- Must have knowledge about the human visual perception
- Must have knowledge about psychophysiological phenomena
- Must have knowledge about sensors for capturing sound, image and psychophysiological data

#### SKILLS

- Must be able to perform microphone calibration
- Must be able to perform camera calibration
- Must be able to collect human psychophysiological data

#### COMPETENCES

- Must be able to analyze a specific problem and based upon this select an appropriate sensor to capture sound, image or psychophysiological data
- Must have competencies in understanding the strengths and weaknesses of different sensors in relation to a specific problem

### TYPE OF INSTRUCTION

The course will be taught through a combination of lectures, demonstrations, and exercises/problem sets.

## EXAM

### PREREQUISITE FOR ENROLLMENT FOR THE EXAM

- Submission of a mini project

### EXAMS

| | |
|---|---|
| Name of exam | Perception and Acquisition of Data |
| 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 | Perception og dataopsamling |
| Module code | MSNAVSK1231 |
| 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 Copenhagen |
| Responsible for the module | Madsen |

## ORGANISATION

| | |
|---|---|
| Study Board | Study Board of Media Technology |
| Department | Department of Architecture, Design and Media Technology |
| 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 |

# COMPUTER VISION

# 2024/2025

## CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The objective of this course module is to provide students with core competencies within the field of computer vision and hereby enabling them to design and implement software systems for automatic or semi-automatic analysis of an image or sequence of images

### LEARNING OBJECTIVES

#### KNOWLEDGE

- Must have knowledge about the terminology within computer vision
- Must be able to understand how a particular computer vision system e.g. the Semester project of the student, relates to similar systems and, if relevant, to the surrounding society
- Must have knowledge about organization of a scientific publication and scientific communication process

#### SKILLS

- Must be able to analyze a problem and (if possible) suggest a solution that uses relevant theories and methods from computer vision
- Must be able to analyze a system that is based on computer vision 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 (if possible) from computer vision
- Must be able to evaluate a computer vision system (or parts hereof) with respect to the afore mentioned assessment criteria

#### COMPETENCES

- Formulate and explain scientific hypotheses and results achieved through scientific work
- Work according to a scientific method and present results in the form of a scientific article and at a seminar/scientific conference
- Read and understand selected scientific literature and next apply the theories, methods, and/or tools in order to solve a selected problem , as well as judge and prioritize the validity of various of scientific information

### TYPE OF INSTRUCTION

As described in §17

## EXAM

### EXAMS

| | |
|---|---|
| Name of exam | Computer Vision |
| 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 | Computer Vision |
| Module code | ESNAVSK1P1 |
| 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 (Computer Engineering) |
| Study Board | Study Board of Electronics and IT |
| Department | Department of Electronic Systems |
| Faculty | The Technical Faculty of IT and Design |

# ACOUSTICS, SOUND PROCESSING AND SOUND PERCEPTION

# 2024/2025

## CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The objective of this module is to allow students to develop competences in engineering disciplines related to acoustics, sound processing, and human sound perception. More specifically students will work within the fields of: electro-acoustics, measurement techniques, signal processing, machine learning and analysis of sound signals, conditioning of sound signals and systems, general acoustics and sound in enclosed spaces, as well as, human sound perception.

### LEARNING OBJECTIVES

#### KNOWLEDGE

- Must understand and be able to use relevant terminology related to acoustics, sound processing, or human sound perception.
- Must be able to understand the similarities and differences of different signal processing strategies for sound signals and their relevance for the specific project.
- Must know how to formulate own competences related to PBL, incl. digital competences

#### SKILLS

- Must be able to analyze a problem and (if possible) suggest a solution that uses relevant theories and methods of human sound perception and/or processing of acoustic signals.
- Must be able to analyze complex acoustic environments and/or sound signals and identify relevant problems and assessment methods.
- Must be able to synthesize, i.e., design and implement, a sound system (or parts hereof) that can address and solve specific acoustic and/or human sound perception problems.
- Must be able to evaluate proposed solutions to acoustic and/or human sound perception problems using validated and/or standardized methods.
- Can reflect over own use of PBL methods and how these methods can be used in 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 acoustics, sound processing, or human sound perception theories, methods, and tools, and synthesize them in a new context to produce new knowledge and solutions.

### TYPE OF INSTRUCTION

As described in §17

## EXAM

### EXAMS

| | |
|---|---|
| Name of exam | Acoustics, Sound Processing and Sound Perception |
| 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 | Akustik, lydbehandling og lydopfattelse |
| Module code | ESNAVSK2P1 |
| 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 (Computer Engineering) |
| Study Board | Study Board of Electronics and IT |
| Department | Department of Electronic Systems |
| Faculty | The Technical Faculty of IT and Design |

# FUNDAMENTALS OF ACOUSTICS AND SOUND

# 2024/2025

## RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on basic knowledge in linear algebra and calculus

## CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

### LEARNING OBJECTIVES

#### KNOWLEDGE

- Must have knowledge about the basic acoustic quantities, their physical significance, and their role in the description of an acoustic process.
- Must be able to understand the relationship between the acoustic variables and the theoretical basis for the development of the wave equation.
- Must have knowledge about the principles of sound emission and reception.
- Must have knowledge of the construction, mechanisms and use of different types of acoustic transducers
- Must have knowledge of the different measurement procedures and techniques used in acoustics.
- Must have knowledge of signal processing techniques in acoustic measurement to obtain time and frequency characteristics of acoustic signals.

#### SKILLS

- Must be able to identify relevant acoustic variables for a given sound source and sound field.
- Must be able to apply the proper assumptions in the calculation or estimation of relevant acoustic variables
- Must be able to select the proper analytical description for the behavior of sound waves in rooms and cavities.
- Must be able to calibrate and use electro-acoustic transducers to obtain reproducible measurement.
- Must be able to select and use exiting transducers based on their parameters.
- Must be able to choose and calibrate the adequate equipment for a given measurement and to be able to identify and eliminate sources of error.

#### COMPETENCES

- Must be able to apply theoretical acoustic principles to model the behavior of acoustic systems, such as pipes, resonators, musical instruments, rooms and other enclosures, ventilation ducts, smartphones etc.
- Must be able to design, carry out and document repeatable acoustic measurements.

### TYPE OF INSTRUCTION

As described in §17

## EXAM

### EXAMS

| | |
|---|---|
| Name of exam | Fundamentals of Acoustics and Sound |
| 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 | Akustik og lyd |
| Module code | ESNAVSK2K2 |
| 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

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