Study programme for

BSc in Engineering (Electronics and IT)

5th – 6th semester

Faculty of Engineering and Science
Aalborg University
September 2011

Foreword:

The supplement to the curriculum for BSc in Engineering (Electronics and IT) is to be followed by international students.

AAU, April 2012

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Head of studies

Contents

Chapter 1: The study programme's legal basis, etc.

1.1 Ministerial order's legal basis

The Bachelor programme in Electronics and IT has been drawn up in accordance with the Ministry of Science's order No. 814 from June 29, 2010 concerning bachelor and master programmes at the universities (order of programme) and order no. 857 from July 1, 2010 concerning exam at university educations (order of exam) with the latest changes. Additional reference is made to Executive order No. 233 of March 24, 2011 (Access Order) and order No. 250 from March 15, 2007 (Rating order) with later amendment.

1.2 Relevant Faculty

The Bachelor programme belongs under Faculty of Engineering and Science, Aalborg University.

1.3 Relevant Study Board

The bachelor programme belongs under the study board for Electronics and IT, School of Information and Communication Technology (SICT).

Chapter 2: Admission, title, duration and competence profile

2.1 Admission

Admission to the bachelor programme requires qualifications equivalent to those obtained on the first 2 years of the bachelor programme in Electronics and IT. Students are evaluated on individual basis.

2.2 The programme title in English

The Bachelor programme entitles students to the following titles:
Bachelor of Science (BSc) in Engineering (Electronic Engineering and IT with specialization in Communication Systems)
Bachelor of Science (BSc) in Engineering (Electronic Engineering and IT with specialization in Signal Processing)
Bachelor of Science (BSc) in Engineering (Electronic Engineering and IT with specialization in Informatics)
Bachelor of Science (BSc) in Engineering (Electronic Engineering and IT with specialization in Control Engineering)

2.3 The prescribed number of ECTS

The bachelor programme is a 3-year research based full-time programme. In ECTS, 180 credits represent the workload of the study programme.

2.4 The programme competence profile

The following will appear on the diploma:

> A bachelor has skills acquired through education that takes place in a research environment.
>
> A bachelor has thorough knowledge and understanding of his subject area methods and scientific basis. These capacities qualify the Bachelor of training at an appropriate candidate for study and employment on the basis of education.

2.5 The education competence profile:

<u>BSc:</u>

Knowledge

- Has knowledge of key theories, methods and practices in the electronics and computer field
- Can understand and reflect on the theories, methods and practices in the electronics and IT area.
- Has knowledge and understanding of analog and digital electronics
- Has an understanding and knowledge of software development including interaction with hardware
- Has knowledge of the mathematical basis of the field
- Has knowledge and understanding of methods for planning and management team organized project

The following also applies to graduates who have specialized in:

- Information Processing Systems: Has knowledge and understanding of theories and methods involved in classification systems
- Embedded real-time signal processing: Has knowledge and understanding of theories and methods used in embedded real-time signal processing systems
- Communication Systems: Has knowledge and understanding of theories and methods used in communication systems.
- Control Engineering: Has knowledge and understanding of theories and methods involved in control systems.

Skills

- Can use modern methods and tools to describe, analyze, model, implement, test and document electronics systems on a scientific basis.
- Can evaluate theoretical and practical problems and give reasons for and choose appropriate solutions based on literature studies, models, analyzes, simulations and/or tests
- Can carry out scientifically based experiments and draw valid conclusions.
- Can communicate professional issues and solutions to peers and non-specialists or partners and users

Competences

- Has a systematic and methodical way of working
- Can handle complex and development-oriented situations in study or work contexts.
- Can independently engage in disciplinary and interdisciplinary collaboration with a professional approach
- Can convert academic knowledge and skills into practical problem solving
- Can identify own learning needs and structure their own learning in different learning environments

Chapter 3: Content and Organization of the programme

The programme is structured in modules and organized as a problem-based study. A module is a programme element or a group of programme elements, which aims to give students a set of professional skills within a fixed time frame specified in ECTS credits, and concluding with one or more examinations within a specific exam period. Examinations are defined in the study programme.

The programme is based on combination of academic, problem-oriented and interdisciplinary approaches and organized based on the following work and evaluation methods that combine skills and reflection:

- lectures
- classroom instruction
- project work
- workshops
- exercises (individually and in groups)
- teacher feedback
- reflection
- portfolio work
- student presentation

3.1 Contents of the education:

All modules are assessed through individual grading according to the 7-point scale or Pass/Fail. All modules are assessed by external examination (external grading) or internal examination (internal grading or by assessment by the supervisor only)

Semester	Module	ECTS	P/C *)	Assessment	Exam
5.	Digital and Analog Systems Interacting with the Surroundings	15	P	7-point scale	External
	Signal Processing	5	C	7-point scale	Internal
	Modeling and Control	5	C	Pass/Fail	Internal
	Communication in electronic systems	5	C	Pass/Fail	Internal
6.	BSc Project (Control Engineering)	20	P	7-point scale	External
	BSc Project (Communication Systems)	20	P	7-point scale	External
	BSc Project (Embedded Real-Time Signal Processing)	20	P	7-point scale	External
	BSc Project (Information Processing Systems)	20	P	7-point scale	External
	Introduction to Probability Theory and Statistics	5	C	7-point scale	Internal
	Matrix Computations and Convex Optimizations	5	C	Pass/Fail	Internal

*) P = Project - C = Course

3.2 Description of modules

Digital and Analog Systems Interacting with the Surroundings
Digitale og analoge systemer i samspil med omverdenen

Extent:	15 ECTS
Semester:	5th Semester
Prerequisites:	Knowledge, skills and competencies equivalent to having passed the 4th Semester.

Purpose:

Electronic systems never exist in a vacuum; to be useful, they invariably have to interact with their surroundings in one form or another. This interaction commonly takes the form of the electronic system receiving some analog or digital signals through measurement devices or other means. The system then translates these signals into discrete data. The data is then either processed directly by the system itself or communicated to other digital systems, for example a remote computer, where processing can take place. Eventually, the system reacts in response to the result of the processing, generating a new set of analog signals via an appropriate actuator, for instance in the form of a control voltage supplied to an electric motor, speech signals in a mobile telephone system, etc.

The purpose of this semester is to build on and expand the skills and competences within digital and analog electronics acquired on previous semesters, and ensure that the students can apply these skills and competences in a complex reality. Specifically, the aim is that the students obtain an understanding of the interaction between computers and their surroundings via various kinds of sensors and actuators, including modeling and control of physical systems, digital signal processing, as well as communicating systems. Completing this project module thus enables the students to analyze, design and implement systems involving both physical elements and computers.

Objective:

Students who complete the module:

Knowledge

- Must have an understanding of digital and analog transfer functions described via the Laplace and z operators, respectively, including features such as poles, zeros, analog and digital implementation, transfer matrices etc.
- Must be able to linearize non-linear system models in order to approximate them by linear models
- Must have insight into real-time aspects in relation to digital systems communicating with other analog and/or digital systems
- Must have insight into different methods for design of analog and digital filters
- Must have knowledge of theories and methods for spectral estimation

- Must have insight into the OSI network model
- Must have fundamental knowledge of wireless communication
- Must have knowledge of protocols on various layers in communicating systems

Skills

- Must be able to use methods for modeling physical systems, including electric, electro-mechanical, thermal and fluid dynamical systems, at a level where the resulting models can be utilized in the design of electronic systems interacting with their surroundings
- Must be able to use the Fourier transformation for analysis of digital signals
- Must have an understanding of exchange and processing of analog signals and discrete data between (sub-)systems, including frequency responses, phase and gain characteristics, sampling, analog and digital filtering etc.
- Must be able to design control laws to achieve specific system requirements, for instance specific phase and gain margin, limited overshoot etc.
- Must be able to use methods for construction of distributed systems making use of communication hardware, multi-programming and basic network protocols
- Must be able to utilize relevant software tools for simulation of the above systems

Competencies

- Must be able to construct systems comprising one or several computer-based systems embedded in physical surroundings, involving transformation between analog and digital signal (and corresponding data representations), such that an a priori specified behavior is achieved by the overall system
- Must be able to use feedback to reduce effects of disturbances, uncertainties and so forth, as well as be able to specify requirements to and achieve desired system responses for linear systems
- Must be able to specify requirements to and implement real-time communication between computer systems

Type of instruction:	Project work completed with study circle, lectures, etc.
Exam format:	Individual oral exam based on the project report.
Evaluation criteria:	As stated in the Framework Provisions.

Signal Processing
Signalbehandling

Extent:	5 ECTS
Semester:	5th Semester
Prerequisites:	Engineering Mathematics for Electronic Engineering 2.
Purpose:	Analysis and filtering of signals is a discipline that is a prerequisite for all specializations in electronic systems. The discipline used in automation, communications, multimedia systems, etc. The course aims to support students in understanding key concepts, theories and methods of analysis and filtering of analog and digital signals, and apply theories and methods of analysis and filtering of analog and digital signals.
Objective:	Students who complete the module:

Knowledge

- Must have knowledge of theories and methods for analyzing and processing of signals on a computer
- Must have knowledge of theories and methods for spectral estimation
- Must have knowledge of theories and methods for design of analog and digital filters (IIR/FIR)
- Must have knowledge of the theories and methods limitations
- Must have knowledge of the relationship between the analysis of signals in time and frequency domain
- Must have knowledge of theories and methods for transformation between different domains.

Skills

- Must be able to use tools for analysis, design and simulation of analog and digital signal processing systems
- Must be able to apply theories and methods for spectral estimation including DFT/FFT
- Must be able to demonstrate the correlation between the frequency resolution, window functions and zero-padding
- Must be able to apply theories and methods for design of analog and digital filters
- Must be able to implement IIR filters using the particular bilinear transformation and impulse invariant methods
- Must be able to explain the importance of phase linearity and group race time
- Must be able to design FIR filters using window methods
- Must be able to explain the correlation between tangle pole / zero diagrams and frequency response
- Must be able to implement filters in practice and including being able to make use of appropriate filter structures, quantization, and scaling.

Competencies

- Must be able to discuss basic theories and methods for analyzing and processing of analog and digital signals using correct terminology
- Must be able to assess opportunities and constraints of the theory and methods applied in practice

Type of instruction:	Project work completed with study circle, lectures, etc.
Exam format:	Individual written or oral exam.
Evaluation criteria:	As stated in the Framework Provisions

Modelling and Control
Modellering og regulering

Extent:	5ECTS
Semester:	5th Semester
Prerequisites:	Dynamic electronic systems, 2^{nd} Semester
Purpose:	The feedback can be understood as the ability to use measurement of the status of a system to correct for errors, and thereby achieve a desired dynamic response for the given stimuli, such as sheets and noise. This means that by designing a feedback – a regulator – a system may be forced to take a specific, desirable behavior. The purpose of this course is to enable the students to use and set the controllers using frequency domain methods, and to configure various controllers and systems described by transfer functions.
Objective:	Students who complete the module:

Knowledge

- Must have knowledge of models of physical systems, including their limitations and applications
- Must have achieved an understanding of the linearization of the models described by differential equations
- Must have knowledge of relevant characteristics of dynamic systems, such as stability, overshoot, frequency response, etc.
- Must be able to develop a linear model of a physical system described by differential equations, and is able to transform this to the Laplace domain.
- Must have insight into the relationship between models in continuous time and the corresponding sampled models

Skills

- Must be able to model physical systems, including electrical, electro mechanical, thermal and fluid-dynamic systems to a level where such models can be used for controller design.
- Must be able to use relevant software tools for simulation of the above systems
- Must have achieved an understanding of the concept of sensitivity in the transfer function relationship
- Must be able to use open-loop frequency characteristics for design of amplification in the feedback
- Must be able to use transfer matrices to describe multivariable dynamic systems

Competencies

- Must have achieved an understanding of the feedback principle, including interference suppression and reduction of parameter variations.
- Must be able to design lead / lag or PID controllers to control the

physical processes taking into account material properties such as static properties, stability, such as phase margin, gain margin, speed, for example bandwidth, cross-over frequency, etc.

Type of instruction:	Lectures, problem solving, workshops, self-study
Exam format:	Individual written or oral exam.
Evaluation criteria:	As stated in the Framework Provisions

Communication in Electronic Systems
Kommunikation i elektroniske systemer

Extent: 5 ECTS
Semester: 5^{th} Semester
Prerequisites: Knowledge, skills and competences sufficient to pass EIT 4th semester

Purpose: Electronic systems communicate more and more with their surroundings as well as with other electronic systems, and it is thus imperative that students obtain understanding of how such communication takes place, and how different technologies and protocols influence how such communication is carried out. The purpose of this course is to provide the students with a basic, but operational knowledge of communicating systems, including hardware, models and protocols, thereby enabling the students to analyze problems related to communicating systems and make relevant design choices. Having completed the course, the students shall be able to develop and implement simple applications that communicate via networks.

Objective: Students who complete this module:

Knowledge

- Must have insight into basic serial communication standards and technologies, such as e.g. UART, ISP, I2C, RS232, RS485, Ethernet etc.
- Must have insight into relevant wireless communication technologies, such as e.g. Bluetooth, IEEE 802.11 etc.
- Must be able to understand general network models and architectures
- Must have insight into network security
- Must have knowledge of field buses and how to employ them
- Must have knowledge of real-time protocols and how to apply them
- Must be able to utilize relevant tools for simulation and modeling of key aspects of communication networks.
- Must have an understanding of the TCP/IP protocol stack and be able to evaluate functions in the network, transport and application layers
- Must have an understanding of the OSI network model and be able to assign functions to the relevant layers in the model

Skills

- Must have understanding of the four bottom layers of the OSI model, i.e., the physical, data link, MAC, and network layers, including how data is communicated horizontally within and vertically between layers.
- Must have understanding of fundamental Medium Access Control principles, such as e.g. TDMA, token bus, round-robin, carrier sense multiple access (with collision detection/collision avoidance) etc.

- Must have understanding of basic aspects of wireless communication, including basic antenna physics
- Must have understanding of various modulation/demodulation principles in wireless communication, such as e.g. AM/FM and various shift keying approaches
- Must be able to utilize socket programming to implement simple network-based applications.
- Must be able to utilize relevant tools for modeling and simulating high-level protocols (corresponding to the session, presentation and application layers in the OSI model)

Competencies

- Must be able to analyze the communication aspects of a distributed system and specify and/or design a communication network to support communication in such a system

Type of instructions:	Lectures, problem solving, workshops, self-study
Exam format:	Individual written or oral exam.
Evaluation criteria:	As stated in the Framework Provisions

BSc Project (Control Engineering)
Bachelorprojekt (Reguleringsteknik)

Extent:	20 ECTS
Semester:	6th Semester
Prerequisites:	
Purpose:	The project must be based on a physical process. The process can be mechanical, thermal, electrical, biologic or chemical. A dynamic model of the process has to be developed. The model has to be adjusted and verified through measurements. Demands as well in the time as in the frequency domain has to be specified. Using the dynamic model classic controllers are designed and implemented on the process. The controllers have to be evaluated and compared to the demands
Objective:	Students who complete the project module will obtain the following qualifications:

Knowledge

- Must have knowledge design of control systems
- Must be able to understand and implement dynamic modeling, classic controller design.

Skills

- Must be able to analyze dynamic systems in time and frequency domain
- Must be able to analyze and apply controller design methods based on root locus
- Must be able to apply mechanical, thermodynamic, biological or chemical equations to develop a dynamic model
- must be able to analyze and apply methods for simulation of dynamic systems
- Must be able to synthesize, i.e., implement and test dynamic models and controllers
- Must be able to evaluate industrial control and supervision methods.
- Must be able to communicate the above knowledge and skills (using terminology of the field), both orally and in a written report

Competencies

- Must be able to analyze and design classic controllers based on a first principle model.
- Must be able to make first principle models
- Must be able to select and extract relevant features and apply these in a new context
- Must be able to plan, structure and execute a project, within the subject-field of this project module

Type of instructions:	Academically supervised student-governed problem oriented project work. Lectures together with teacher/supervisor guided self-studies and/or mini projects.
Exam format:	Individual oral exam based on the project report
Evaluation criteria:	As stated in the Framework Provisions

BSc Project (Communication Systems)
Bachelorprojekt (Kommunikationssystemer)

Extent:	20 ECTS
Semester:	6. semester
Prerequisites:	EIT 5. semester or similar

Purpose: Besides the traditional human-to-human communication (e. g. phone) or human-to-machine communication (e. g. web browsing), communication is also an indispensable subsystem of systems consisting of multiple distributed components. An example is a home automation system in which various sensors and actuators communicate through wireless links. Such a communication should satisfy multiple requirements. The data should arrive **timely** in order to be relevant for the control actions in the home automation system. Also, the data should be sent **reliably**, despite the possible transmission errors on the links. Finally, the communication should be **energy efficient**, in order not to drain quickly the batteries of the devices. The purpose of the project module is that the students consider a system or scenario in which communication among distributed components is required. The students need first to **identify the requirements and the desired behavior** of the communication (sub-)system that will be applied in that scenario. Next, the students need to consider one or more variants of the communication subsystems by **analyzing the tradeoffs between different designs and parameters**. Finally, the students need to **evaluate the performance** of the obtained communication subsystem, or, depending on the scenario, also the performance of the whole system that uses that subsystem. The previous steps may be repeated in several iterations.

Objective: Students who complete the project module will obtain the following qualifications:

Knowledge

- Must understand how to analyze the requirements posed to the communication system in a given scenario and propose a topology/network that can serve as a basis to carry out the communication in the given scenario
- The student must be able to understand whether and how a certain communication technology can be applied in a given system. For example, whether the system setup allows mains-powered devices or some of the devices must be battery-powered, whether for a given subsystem a wired, wireless or combined solution is required, etc.
- Must have knowledge about the building blocks in a generic communication system and the way they interact together in fulfilling the communication tasks. This consists of two steps: (1) identification of a technology that can serve as a starting basis to be evolved towards a communication solution that satisfies certain requirements; (2) identification of the key parts of the system/protocol stack that needs to be modified in order to meet the requirements.

- Must have knowledge of the methodology to evaluate the performance of a certain communication system in terms of rate, throughput, good put, delay, packet dropping probability, etc.
- Must be able to understand the fundamental tradeoffs that are faced when designing/implementing a communication system: achieving reliability at an expense of an increased delay; reliability of packet transmission vs. the packet size and the associated overhead, etc.

Skills

- Must be able to analyze the communication scenario and specify the target requirements in terms of data rate, delay, error performance, etc.
- Must be able to analyze which communication topology is suitable to be applied in a given scenario, and identify the key parts of the protocol stack that need to be synthesized in order to meet the target requirements.
- Must be able to synthesize a communication system (or parts thereof) by applying some or all of the following techniques:
    - Segmenting the data into packets at the sender side and reassembling the data at the receiver side;
    - Apply techniques for flow control and management of data buffers
    - Apply techniques for error control through coding and ARQ protocols
    - Map the data to the physical transmission medium by using appropriate physical layer techniques (modulation, equalization, etc.) at the transmitter/receiver side
    - Propose and analyze protocols for accessing a shared communication medium and divide the communication resources among multiple users and connections.
    - Must be able to analyze the tradeoffs that arise from choosing different solutions and/or parameters
- Must be able to evaluate a communication system (or parts thereof) in terms of the target performance measures (delay, rate, error performance, etc.) and validate that the design/implementation is operational according to the requirements
- Must be able to communicate the above knowledge and skills (using terminology of the field), both orally and in a written report

Competences

- Must be able to identify, design, implement, and evaluate a viable solution for a communication system in a new context

- Must be able to plan, structure and execute a project, within the subject-field of this project module

Type of instructions:	Academically supervised student-governed problem oriented project work. Lectures together with teacher/supervisor guided self-studies and/or mini projects.
Exam format:	Individual oral examination in the project report
Evaluation criteria:	As stated in the Framework Provision

BSc Project (Embedded real-time Signal Processing)
Bachelorprojekt (Indlejret realtids signalbehandling)

Extent:	20 ECTS
Semester:	6^{th} Semester
Prerequisites:	Has followed the courses up to and including 5^{th} Semester undergraduate course in electronics or equivalent
Purpose:	An embedded system is defined as an electronic system which is based on a computer, but the system is not in itself a computer, e.g., like a PC. According to this definition, an average person is interacting with hundreds of embedded systems on a daily basis, typically in terms of audio/video applications, wireless/mobile communication, gaming consoles, household machines, automotive and medical devices, as well as avionic and satellite based systems. In most cases, the computer embedded in such devices is conducting some kind of signal processing, i.e., an analogue signal is registered by a sensor and sampled, and next the signal is either analyzed or modified digitally by software executing on the computer. Eventually the resulting signal is finally re-converted back to the analogue domain. An interesting feature of this overall process is that in most cases it must be conducted in hard real-time, i.e., the processing must be completed within a predefined and fixed time interval. Otherwise, the system will fail, potentially leading to hazardous situations. Taking the outset in a real-life problem/application, the purpose of this project module is to specify, design, simulate, implement, test and document (part of) an embedded real-time signal processing system. In this context, the algorithm(s) which are to perform the signal processing have to be developed, simulated/evaluated (preferably using C or Matlab) and optimized, and next compiled into an executable code which can run in real-time on a programmable digital signal processor. The overall design parameters may include, but are not limited to execution time, code size, numerical robustness, and eventually energy consumption. Primarily, the project will focus on the signal processing theories and algorithms, as well as the development of optimal source- and object codes using commercially available development boards/tools, thus excluding the design and implementation of user-specific hardware.
Objective:	Students who complete the project module will obtain the following qualifications:

Knowledge

- Must have knowledge about the building blocks used in a generic embedded real-time digital signal processing (DSP) system, their mutual interaction and interfaces, as well as relevant performance parameters.
- Must have knowledge about theories and methods used to design numerically robust and resource optimal DSP algorithms suitable for being executed real-time on programmable digital signal processors.

Skills

- Must be able to analyze a technical problem which naturally finds its solution in terms of real-time digital signal processing. Secondly, to formulate a set of specifications for the algorithms to be developed, and possibly also for the hardware/software platform to be used.
- Must be able to apply various methods to design, simulate, and evaluate DSP algorithms according to the specifications for functionality and numerical properties. C or Matlab are candidates for executable specifications and for simulation purposes.
- Must be able to analyze DSP algorithms from a computational complexity, structural, and data flow oriented point of view in order to specify architectural requirements for a software programmable target platform.
- Must be able to apply design tools, such as C compilers (eventually using in-line assembly language), in order to synthesize and optimize real-time executable code for DSP algorithms.
- Must be able to evaluate 1) an overall system solution, and 2) the design methods applied to derive the solution. This must be done in terms of relevant metrics such as execution time, memory usage, numerical robustness, and energy consumption. Secondly, from a micro-computer architectural point of view, the students must be able to evaluate the match between algorithms and architectures.
- Must be able to communicate the above mentioned knowledge and skills (using the terminology of the domain), both orally and in a written report.

Competencies

- Must be able to identify, design, implement, and evaluate a viable solution for an embedded real-time signal processing system in a real-life context.
- Must be able to plan, structure, and conduct a project within the scientific subject of this project module.

Type of instructions:	Academically supervised student-governed problem oriented project work. Lectures together with teacher/supervisor guided self-studies and/or mini projects.
Exam format:	Individual oral examination in the project report
Evaluation criteria:	As stated in the Framework Provisions

BSc Project (Information Processing Systems)
Bachelorprojekt (Informationsbehandlende systemer)

Extent:	20 ECTS
Semester:	6th Semester
Prerequisites:	

Purpose: One of the cornerstones in modern engineering is automatic interpretation of measurable signals. As an example consider recycling of glass bottles. When you place a used bottle in a reverse vending machine in your local grocery store, a sensor(here a camera) takes a picture of the bottle and automatically extracts characteristics (known as features) such as dimensions, shape, color etc. These features are then fed to a classification process where they are compared with prototypical features stored in a database. The classifier then makes a decision regarding the type of bottle and whether it is broken or not.

The purpose of this project module is for the students to work with a concrete problem where they first extract relevant features from some input signal, e.g., audio or video, and then classify the input into a number of different categories.

Objective: Students who complete the project module will obtain the following qualifications:

Knowledge

- Must have knowledge about the building blocks in a generic classification system
- Must be able to understand how a particular classification system e.g. the semester project of the student, relates to similar systems and to the surrounding society

Skills

- Must be able to analyze a problem and, if possible, suggest a solution that uses relevant theories and methods within the fields of feature extraction and classification
- Must be able to analyze a system that includes feature extraction and/or classification and identify relevant constraints and assessment criteria. This relates to the technical aspects of the system and (if relevant) the usefulness to society
- Must be able to synthesize, i.e., design and implement, a system (or parts thereof) using relevant feature extraction and classification theories and methods
- Must be able to evaluate a classification system (or parts thereof) with respect to the afore mentioned assessment criteria

Competencies

- Must be able to select and extract relevant features and apply these in a new context
- Must be able to communicate the above knowledge and skills

(using terminology of the field), both orally and in a written report

Type of instructions:	Academically supervised student-governed problem oriented project work. Lectures together with teacher/supervisor guided self-studies and/or mini projects.
Exam format:	Individual oral examination in the project report.
Evaluation criteria:	As stated in the Framework Provisions

Introduction to Probability Theory and Statistics
Introduktion til sandsynlighedsregning og statistik

Extent:	5 ECTS
Semester:	6th Semester
Prerequisites:	Fundamentals in Linear Algebra, Calculus, and Fourier Theory
Purpose:	After attending the course the students have developed the engineering intuition of the fundamental concepts and results of Probability, Statistics, and Stochastic Processes. They are able to apply the taught material to model and solve simple engineering problems involving randomness.
Objective:	Students who complete the course module will obtain the following qualifications:

Knowledge

- Must have knowledge about the concept of probability spaces

- Must have knowledge about the conceptual models of estimation and hypothesis testing
- Must be able to understand the basic concepts of probability theory:
  - Probability of events
  - Random variables
- Must be able to understand the basic concepts of statistics:
- Binary hypothesis testing.

Skills

- Must be able to apply/compute
  - Bayes rule in simple contexts
  - The probability that Binomial, Poisson, and Gaussian random variables take values in a specified interval
  - The mean and variance of Binomial, Poisson, and Gaussian random variables
  - The marginal distributions of multi-variate Gaussian variables

- Must be able to apply and interpret
- ML-estimation in simple contexts involving the Binomial, Poisson, and Gaussian distribution
- Binary-hypothesis tests in simple contexts involving the Binomial, Poisson, and Gaussian distribution

Competencies

- Must be able to apply the general concepts of Probability Theory and Statistics in a new simple context. This includes choosing the suitable methods, evaluating the outcomes, and drawing the appropriate conclusions.

Type of instructions:	Combination of e.g. face-to-face lectures, exercises, self-studies and mini-projects (using e.g. MATLAB).
Exam format:	Individual written or oral examination.
Evaluation criteria:	As stated in the Framework Provisions

Matrix Computations and Convex Optimization
Matriksberegninger og konveks optimering

Extent:	5 ECTS
Semester:	6th Semester
Prerequisites:	Linear Algebra / Calculus
Purpose:	Engineering systems and design problems can often be compactly described analyzed and manipulated using matrices and vectors. Moreover, tractable solutions to design problems can be obtained by casting the design problems as optimization problems. For the class of linear and quadratic problems, the solutions can be obtained by solving systems of equations. In computer programs, this is achieved via matrix factorizations. For the larger class of convex problems, no closed-form solution may exist and numerical methods must be applied. This course aims at teaching numerically robust methods for solving systems of equations and, more generally, convex optimization problems, including also standard constrained problems.
Objective:	Students who successfully complete the course will have obtained the following qualifications:

Knowledge

- Knowledge about convex functions and sets, norms, special matrices
- Understand how to classify and solve systems of equations and convex optimization problems
- Understand numerical aspects of solving systems of equations and convex optimization problems
- Knowledge about Lagrange multipliers
- Understand matrix factorizations and their properties

Skills

- Identify optimization problems and cast them into standard form
- Identify types of extreme (minima, maxima, local, global, etc.)
- Apply eigenvalue and singular value decomposition to relevant matrix problems
- Have understanding of state space descriptions of systems of linear differential equations
- Apply numerically robust methods to solve systems of equations
- Apply and implement the following numerical optimization methods to unconstrained optimization problems: Steepest Descent, Newton's method, Gauss-Newton method
- Apply and interpret least-squares in solving over-determined systems of equations
- Apply the Lagrange multiplier method to constrained convex optimization problems

Competencies

- Apply linear algebra theory to analyze engineering systems in their field
- State and analyze engineering design problems in their field as systems of equations or standard optimization problems
- Select the appropriate matrix factorization or numerical optimization method to solve engineering design problems in their field

Type of instructions:	Lectures with exercises. Student projects on engineering application in their field
Exam format:	Individual written or oral examination
Evaluation criteria:	As stated in the Framework Provisions

Chapter 4: Entry into Force, Interim Provisions and Revisions

The study programme is approved by the Dean of the Faculty of Engineering and Science and enters into force as of September 2011.

In accordance with the Framework Provisions and the Handbook on Quality Management for the Faculty of Engineering and Science and The Faculty of Medicine at Aalborg University, the study programme must be revised no later than 5 years after its entry into force.

Chapter 5: Other provisions

5.1 Rules concerning written work, including the bachelor's

In the assessment of all written work, regardless of the language it is written in, weight is also given to the student's formulation and spelling ability, in addition to the academic content. Orthographic and grammatical correctness as well as stylistic proficiency form the basis of the evaluation of language performance. Language performance must always be included as an independent dimension of the total evaluation. However, no examination can be assessed as "Pass" on the basis of good language performance alone; similarly, an examination normally cannot be assessed as "Fail" on the basis of poor language performance alone.
The Board of Studies can grant exemption from this in special cases (e.g., dyslexia or a native language other than Danish).

The Bachelor's project must include an English summary[1]. If the project is written in English, the summary must be in Danish[2]. The summary must be at least 1 page and not more than 2 pages (this is not included in any fixed minimum and maximum number of pages per student). The summary is included in the evaluation of the project as a whole.

5.2 Rules concerning credit transfer (merit), including the possibility for choice of modules that are part of another programme at a university in Denmark or abroad

In each individual case, the Board of Studies can approve successfully completed (passed) programme elements from other Master's programmes in lieu of programme elements in this programme (credit transfer). The Board of Studies can also approve successfully completed (passed) programme elements from another Danish programme or a programme outside of Denmark at the same level in lieu of programme elements within this curriculum. Decisions on credit transfer are made the Board of Studies based on an academic assessment. See the Framework Provisions for the rules on credit transfer.

5.3 Rules concerning the progress of the Bachelor's programme

The student must participate in all first year examinations by the end of the first year of study in the Bachelor's programme, in order to be able to continue the programme. The first year of study must be passed by the end of the second year of study, in order that the student can continue his/her Bachelor's programme.

In special cases, however, there may be exemption from the above, if the student has been on a leave of absence. Leave is granted during first year of study only in the event of maternity, adoption, military service, UN service or where there are exceptional circumstances.

[1] Or another foreign language (French, Spanish or German) upon approval by the Board of Studies
[2] The Board of Studies can grant exemption from this

5.4. Rules concerning the completion of the Bachelor’s programme
The Bachelor’s programme must be completed no later than six years after it was begun.

5.5 Special project process
In the 3rd, 4th and 5th semesters, the student can upon application, design an educational programme where the project work is replaced by other study activities; cf. the Framework Provisions section 9.3.1.

5.6 Examination rules
The rules for examinations are stated in the Examination Policies and Procedures published by the Faculty of Engineering and Science on their website.

5.7 Exemption
In exceptional circumstances, the Board of Studies can grant exemption from those parts of the study programme that are not stipulated by law or ministerial order. Exemption regarding an examination applies to the immediate examination.

5.8 Rules and requirements for the reading of texts
It is assumed that the student can read academic texts in his or her native language as well as in English, and use reference works etc. in other European languages.

5.9 Additional information
The current version of the study programme is published on the Board and Studies’ website, including more detailed information about the programme, including exams.