Curriculum for the master’s programme in Acoustics and Audio Technology

Aalborg University, September 2012
Preface:
Pursuant to Act 695 of June 22, 2011 on Universities (the University Act) with subsequent changes, the following curriculum for the Master's programme is stipulated. The programme also follows the Framework Provisions and the Examination Policies and Procedures for the Faculty of Engineering and Science and The Faculty of Medicine.

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Chapter 1: Legal Basis of the Curriculum, etc.

1.1 Basis in ministerial orders
The Master’s programme is organised in accordance with the Ministry of Science, Technology and Innovation’s Ministerial Order no. 814 of June 29, 2010 on Bachelor’s and Master’s Programs at Universities (the Ministerial Order of the Study Programs) and Ministerial Order no. 857 of July 1, 2010 on University Examinations (the Examination Order) with subsequent changes. Further reference is made to Ministerial Order no. 213 of February 21, 2012 (the Admission Order) and Ministerial Order no. 250 of March 15, 2007 (the Grading Scale Order) with subsequent changes.

1.2 Faculty affiliation
The Master’s programme falls under the Faculty of Engineering and Science, Aalborg University.

1.3 Board of Studies affiliation
The Master’s programme falls under the Board of Studies for Electronics and IT.

Chapter 2: Admission, Degree Designation, Programme Duration and Competence Profile

2.1 Admission
Admission to the Master’s programme requires a Bachelor’s or Bachelor of Engineering degree in Electronic Engineering and IT, Computer Engineering or the like.

Students with another Bachelor's degree, upon application to the Board of Studies, will be admitted after a specific academic assessment if the applicant is deemed to have comparable educational prerequisites. The University can stipulate requirements concerning conducting additional exams prior to the start of study.

2.2 Degree designation in Danish and English
The Master’s programme entitles the graduate to the designation civilingeniør, cand.polyt. (candidatus/candidata polytechnices) i akustik og audioteknologi. The English designation is: Master of Science (MSc) in Engineering (Acoustics and Audio Technology).

2.3 The programme’s specification in ECTS credits
The Master’s programme is a 2-year, research-based, full-time study programme. The programme is set to 120 ECTS credits.

2.4 Competence profile on the diploma
The following competence profile will appear on the diploma:

A graduate of the Master’s programme has competencies acquired through an educational programme that has taken place in a research environment.

The graduate of the Master’s programme can perform highly qualified functions on the labour market on the basis of the educational programme. Moreover, the graduate has prerequisites for research (a Ph.D. programme). Compared to the Bachelor’s degree, the graduate of the Master’s programme has developed her/his academic knowledge and independence, so that the graduate can independently apply scientific theory and method in both an academic and occupational/professional context.
2.5 Competence profile of the programme:

The graduate of the Master’s programme:

Knowledge

- has a broad knowledge in the area of acoustics and audio, including physics, electronics, signal processing, transmission, hearing, perception and effects.
- has knowledge in the field of sound and audio technologies including sound production, measurement and instrumentation
- has knowledge in one or more of the subject areas, that is based on the highest international research in acoustics and audio
- can understand and, on a scientific basis, reflect on the knowledge within acoustics and audio, and identify scientific problems

Skills

- can select and apply analytical, numerical and experimental methods for analysis and design of complex systems.
- can demonstrate insight into the area of sound and vibration
- excels in signal analysis and processing
- can initiate and implement engineering solutions on adequate technology platforms
- can use appropriate psycho physical methods for subjective evaluations of sound
- can evaluate and select among the relevant scientific theories, methods, tools and general skills and, on a scientific basis, advance new analyses and solutions
- can communicate research-based knowledge and discuss professional and scientific problems with both peers and non-specialists

Competencies

- can work within research and development in international companies within the acoustics and audio industry
- can work within consultancy related to acoustics and audio primarily within environmental noise and architectural acoustics
- can contribute to legislation and standardization work within the acoustics and audio area
- can work in the audiology industry and the health care systems with diagnosis and solutions related to the human auditory system
- can manage work and development situations that are complex, unpredictable and require new solutions.
- can independently initiate and implement discipline-specific and interdisciplinary cooperation and assume professional responsibility.
- can independently take responsibility for own professional development and specialization
Chapter 3: Content and Organization of the Programme

The programme is structured in modules and organised 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 specific exam periods. Examinations are defined in the curriculum.

The programme is based on a combination of academic, problem-oriented and interdisciplinary approaches and organised 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
Overview of the programme:

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).

<table>
<thead>
<tr>
<th>Semester</th>
<th>Module</th>
<th>ECTS</th>
<th>P/C *)</th>
<th>Assessment</th>
<th>Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>Select 1 Digital Signal Processing Applied to Acoustical Signals</td>
<td>15</td>
<td>P</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>Select 1 PBL and Digital Signal Processing Applied to Acoustical Signals</td>
<td>15</td>
<td>P</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>Stochastic Processes</td>
<td>5</td>
<td>C</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>Fundamentals of Acoustics and Electro-acoustics</td>
<td>5</td>
<td>C</td>
<td>Pass/Fail</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>Select 1 Machine Learning (elective)</td>
<td>5</td>
<td>C</td>
<td>Pass/Fail</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>Select 1 Optimisation Methods (elective)</td>
<td>5</td>
<td>C</td>
<td>Pass/Fail</td>
<td>Internal</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>Select 1 Sound Technology for the Normal Hearing (elective)</td>
<td>20</td>
<td>P</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td></td>
<td>Select 1 Sound Technology for the Hearing-impaired (elective)</td>
<td>20</td>
<td>P</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td></td>
<td>Human Sound Perception and Audio Engineering</td>
<td>5</td>
<td>C</td>
<td>Pass/Fail</td>
<td>Internal</td>
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<td></td>
<td>Scientific Computing and Sensor Modelling</td>
<td>5</td>
<td>C</td>
<td>Pass/Fail</td>
<td>Internal</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>Audio Systems, Acoustics in Health Care, Development or Consultancy</td>
<td>20</td>
<td>P</td>
<td>7-point scale</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>Select 2 Applied Experimental Psychology and Psychophysics (elective)</td>
<td>5</td>
<td>C</td>
<td>Pass/Fail</td>
<td>Internal</td>
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<tr>
<td></td>
<td>Select 2 Array and Sensor Signal Processing (elective)</td>
<td>5</td>
<td>C</td>
<td>Pass/Fail</td>
<td>Internal</td>
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<tr>
<td></td>
<td>Select 2 User Experience Design for Multi-modal Interaction (elective)</td>
<td>5</td>
<td>C</td>
<td>Pass/Fail</td>
<td>Internal</td>
</tr>
<tr>
<td></td>
<td>Select 2 Platforms and Methods for Multi Modal Systems Architectures (elective)</td>
<td>5</td>
<td>C</td>
<td>Pass/Fail</td>
<td>Internal</td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Master’s Thesis</td>
<td>30, possibly 50</td>
<td>P</td>
<td>7-point scale</td>
<td>External</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>120</td>
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*) P = Project -  C = Course
Descriptions of modules

Digital Signal Processing Applied to Acoustical Signals (P)

Digital signalbehandling af akustiske signaler

Prerequisites:
Competencies in Project-Oriented and Problem-Based Learning.

Objective:
Students who complete the module:

Knowledge
- Must have knowledge about the field of digital signal processing and elements of advanced signal processing and how and when to apply such to acoustical signals.
- Must have knowledge about solution strategies, their evaluation and comparison, possibly by computer simulation.
- Must comprehend conversions from digital to analog domain, and vice versa, and the physical values (and their sizes) that the conversions imply.
- Must understand the scientific communication processes related to conference presentations and related to publishing in peer-reviewed scientific journals.
- Must know how to organize a scientific publication.

Skills
- Must be able to identify and describe the project relevant challenges with respect to acoustical and signal processing solutions.
- Must have experience with trade-offs between acoustical vs. signal processing based solutions.
- Must be able to apply selected measurement (and possibly reproduction) principles of project-relevant sound fields.
- Must be able to identify which parameters are of importance and which are not, e.g. positioning of loudspeaker(s), surroundings, sensitivity to noise etc.
- Must be able to select the correct transducers and equipment based on their properties and limitations.
- Must be able to test to which extent the given set-up (e.g. recording/playback) follows the set of requirements as defined by the project.
- Must be able to identify and select between deterministic and stochastic solutions to the acoustical problem(s).
- Can explain the process of and criteria for peer reviewed scientific communications.
- Can write a paper for a scientific conference/journal.
- Can prepare and give an oral and poster presentation for a scientific conference.

Competencies
- Must be able to carry out calibrated capturing and playback of acoustical signals, either by a computer or by dedicated electronic equipment.
- Must be able to decide on which basic theories and practical methods to apply to acoustical signals.
- Must be able to implement a digital signal processing algorithm, either in real-time (e.g. PC, DSP or Smartphone) or by simulation.
- Are able to judge and prioritize the validity of various sources of scientific information.
• Apply internationally recognized principles for acknowledging and citing work of others properly.
• Can formulate and explain scientific hypotheses and results achieved through scientific work
• Are able to analyze results and draw conclusions on a scientific basis

**Type of instruction:**
Students are organized in groups of up to six members working according to the POPBL concept at Aalborg University. Each group will be supervised by at least one staff member doing research within the main topic(s) addressed in the project.

On this semester the project has to be documented in the following forms (all in English):

• A scientific article
• An oral presentation
• A poster
• Edited worksheets, providing all relevant project details

For further information see the introduction to Chapter 3.

**Exam format:**
Individual oral examination based on written documentation including: a scientific article, slides from the oral presentation at the student conference (SEMCON), a poster and edited worksheets.

**Evaluation criteria:**
As stated in the Framework Provisions
PBL and Digital Signal Processing Applied to Acoustical Signals (P)
Digital signalbehandling af akustiske signaler (med fokus på problem baseret læring)

Prerequisites:
A BSc. Degree in Electronic Engineering covering fundamental signal processing or communication topics. Students with other Bachelor degrees will be admitted on an individual basis.

Objective:
Students who complete the module:

Knowledge
- Must have knowledge about the field of digital signal processing and elements of advanced signal processing and how and when to apply such to acoustical signals.
- Must have knowledge about solution strategies, their evaluation and comparison, possibly by computer simulation.
- Must comprehend conversions from digital to analog domain, and vice versa, and the physical values (and their sizes) that the conversions imply.
- Has knowledge of the phases that a project will go through
- Understand various theories and methods applied in problem based learning and group organized project work

Skills
- Must be able to identify and describe the project relevant challenges with respect to acoustical and signal processing solutions.
- Must have experience with trade-offs between acoustical vs. signal processing based solutions.
- Must be able to apply selected measurement (and possibly reproduction) principles of project-relevant sound fields.
- Must be able to identify which parameters are of importance and which are not, e.g. positioning of loudspeaker(s), surroundings, sensitivity to noise etc.
- Must be able to select the correct transducers and equipment based on their properties and limitations.
- Must be able to test to which extent the given set-up (e.g. recording/playback) follows the set of requirements as defined by the project.
- Must be able to identify and select between deterministic and stochastic solutions to the acoustical problem(s)
- Are able to plan and take part in a small group of students working on a problem based project
- Can reflect on experiences obtained through problem based learning and group project work
- Can communicate the result of the project work in an appropriate form
- Are able to demonstrate skills in project management

Competencies
- Must be able to carry out calibrated capturing and playback of acoustical signals, either by a computer or by dedicated electronic equipment.
- Must be able to decide on which basic theories and practical methods to apply to acoustical signals.
Must be able to implement a digital signal processing algorithm, either in real-time (e.g. PC, DSP or Smartphone) or by simulation
Can organize and contribute to a team based project work
Has competencies in project work and problem based learning in a global/multicultural environment
Can manage work and development situations that are complex, unpredictable and require new solutions.
Can independently initiate and implement discipline-specific and interdisciplinary cooperation and assume professional responsibility.
Can independently take responsibility for own professional development and specialization
Can find, evaluate and reference literature within the professional field
Apply internationally recognized principles for acknowledging and citing work of others properly.

**Type of instruction:**
Project work.

**Exam format:**
Individual oral examination based on a written report.

**Evaluation criteria:**
As stated in the Framework Provisions
Stochastic Processes (C)
Stokastiske processer

Prerequisites:
Solid knowledge in probability, statistics, linear algebra, Fourier theory, and programming

Objective:
Students who complete the module:

Knowledge
- Have knowledge about the theoretical framework in which stochastic processes are defined.
- Be able to understand the properties of the stochastic processes introduced in the course, such as white-sense stationary (WSS) processes, Auto Regressive Moving Average (ARMA) processes, Markov models, and Poisson point processes.
- Be able to understand how WSS processes are transformed by linear time-invariant systems.
- Be able to understand the theoretical context around the introduced estimation and detection methods ((non-parametric and parametric) spectral estimation, Linear Minimum Mean Square Error (LMMSE) estimation, Wiener filter, Kalman filter, detection of signals, ARMA estimation, etc.)

Skills
- Be able to apply the stochastic processes taught in the course to model real random mechanisms occurring in engineering problems.
- Be able to simulate stochastic processes using a standard programming language.
- Be able to apply the taught estimation and detection methods to solve engineering problems dealing with random mechanisms.
- Be able to evaluate the performances of the introduced estimation and detection methods.

Competencies
- Have the appropriate "engineering" intuition of the basics concepts and results related to stochastic processes that allow – for a particular engineering problem involving randomness – to design an appropriate model, derive solutions, assess the performance of these solutions, and possibly modify the model, and all subsequent analysis steps, if necessary

Type of instruction:
As described in the introduction to Chapter 3.

Exam format:
Individual oral or written examination.

Evaluation criteria:
As stated in the Framework Provisions
Prerequisites:
The necessary qualifications for acceptance into the master programme.

Objective:
Students who complete the module:

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 be able to understand how acoustical transducers work in three domains: The electrical, the mechanical and the acoustical, and thus be able to transform between the three domains
- 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
- Must have knowledge about acoustical filters and their use

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 room and cavities
- Must be able to model and measure acoustical transducers
- Must be able to measure the electro-acoustic parameters of loudspeakers
- Must be able to calibrate and use electro-acoustic transducers to obtain reproducible measurement

Competencies
- 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 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
- Must be able to design, carry out and document repeatable acoustic measurements

Type of instruction:
As described in the introduction to Chapter 3.

Exam format:
Individual oral or written examination.
Evaluation criteria:
As stated in the Framework Provisions
Machine Learning (C)
Maskin læring

Prerequisites:
Basic knowledge in probability theory, statistics, and linear algebra.

Objective:
The course gives a comprehensive introduction to machine learning, which is a field concerned with learning from examples and has roots in computer science, statistics and pattern recognition. The objective is realized by presenting methods and tools proven valuable and by addressing specific application problems.

Students who complete the module:

Knowledge
- Must have knowledge about supervised learning methods including K-nearest neighbors, decision trees, linear discriminant analysis, support vector machines, and neural networks.
- Must have knowledge about unsupervised learning methods including K-means, Gaussian mixture model, hidden Markov model, EM algorithm, and principal component analysis.
- Must have knowledge about probabilistic graphical models, variational Bayesian methods, belief propagation, and mean-field approximation.
- Must have knowledge about Bayesian decision theory, bias and variance trade-off, and cross-validation.
- Must be able to understand reinforcement learning.

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.

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

Type of instruction:
As described in the introduction to Chapter 3.

Exam format:
Individual oral or written examination.

Evaluation criteria:
As stated in the Framework Provisions
Optimisation Methods (C)
Optimeringsmetoder

Prerequisites:
Basic linear algebra and numerical methods

Objective:
Students who complete the module:

Knowledge
- Must have knowledge about different classes of optimization problems.
- Must have knowledge about objective function, global/local minima, constrained/unconstrained, convex/non-convex functions and sets.
- Must have knowledge about the consequences of dimensionality.
- Must have knowledge about gradient and optimal gradient methods.
- Must have knowledge about Newton and interior-point methods for constrained optimization.
- Must have knowledge about sine search methods and stop criteria.
- Must have knowledge about tools for non-linear optimization.
- Must have knowledge about methods for solving combinatorial optimization problems, such as Simulated Annealing (SA), Genetic Algorithms (GA), ant colony optimization, and Integer Linear Programming (ILP).

Skills
- Must be able to identify problem classes.
- Must be able to apply optimization methods in order to design and implement algorithms for continuous and discrete optimization.
- Must be able to evaluate the performance of optimization algorithms.
- Must be able to transform optimization problems to standard form and use off-the-shell optimization software.
- Must be able to evaluate and understand numerical aspects of optimization algorithms.

Competencies
- Must have an understanding of how to formulate optimization problems in signal processing.
- Must have competencies in applying optimization in signal processing applications.

Type of instruction:
As described in the introduction to Chapter 3.

Exam format:
Individual oral or written examination.

Evaluation criteria:
As stated in the Framework Provisions
Sound Technology for the Normal Hearing (P)
Lydteknologi for normalthørende

Prerequisites:  
Corresponding to having passed the 1st semester one

Objective:  
Students who complete the module:

Knowledge  
- Must have broad knowledge in the area of acoustics, audio engineering, hearing and human sound perception.
- Must have knowledge in the field of sound and audio technologies including multi channel sound recording and reproduction, measurement, instrumentation and standards

Skills  
- Must be able to select and apply analytical, numerical and experimental methods for analysis and design of complex audio systems.
- Must demonstrate insight into the area of human sound perception.
- Must be able to initiate and implement appropriate technical implementations for audio solutions, e.g. within binaural or multi-channel recording and reproduction techniques
- Must demonstrate insight in existing everyday standard and advance solutions in audio systems, e.g. HiFi, public address, CarFi, communication systems, and personal hearing devices (incl. portable devices).
- Must be able to consider the impact of normal loudness perception and possible masking phenomena in the engineering solution(s).
- Must be able to consider spatial aspects of the sound image in the engineering solution(s).

Competencies  
- Must be able to apply proper technical solutions in the field of audio engineering based on normal human sound perception.
- Must be able to communicate the results of the project work in a project report
- Must be able to contribute successfully to teamwork within the problem area and make a common presentation of the result of the project work

Type of instruction:  
Project work.

Exam format:  
Individual oral examination based on a written report

Evaluation criteria:  
As stated in the Framework Provisions
Sound Technology for the Hearing-impaired (P)
Lydteknologi for hørehæmmede

Prerequisites:
Corresponding to having passed the 1st semester

Objective:
Students who complete the module:

Knowledge
- Must have broad knowledge in the area of acoustics, audio engineering, normal and impaired human sound perception.
- Must have insight in most common hearing pathologies, and the personal and social consequences of hearing loss.
- Must have knowledge of hearing diagnosis tools and their application.
- Must have knowledge in the field of sound and hearing aid technologies
- Must have insight into multi-channel sound recording and reproduction, measurement, instrumentation and standards.
- Must have knowledge in the field of general audiology
- Must have insight into auditory models and their applications

Skills
- Must be able to select and apply analytical, numerical and experimental methods for analysis and design of complex audio systems.
- Must be able to apply different methods for hearing diagnosis, e.g. hearing thresholds, tympanometry, oto-acoustic emission measurements.
- Must demonstrate insight into the area of impaired hearing.
- Must be able to initiate and implement appropriate technical implementations, incl. advanced signal processing for the hearing impaired
- Must be able operate and calibrate audio logical equipment
- Must demonstrate insight in existing everyday standard and advance solutions in audio systems, e.g. HiFi, Public address, CarFi, personal assisted hearing devices (portable devices, incl. hearing aids and smartphones).

Competencies
- Must have the necessary competences to design and conduct an audio logical experiment with human subjects
- Must be able to apply proper technical solutions in the field of audio engineering based on impaired human sound perception.
- Must be able to communicate the results of the project work in a project report
- Must be able to contribute successfully to teamwork within the problem area and make a common presentation of the result of the project work

Type of instruction:
Project work.

Exam format:
Individual oral examination based on a written report

Evaluation criteria:
As stated in the Framework Provisions
Human Sound Perception and Audio Engineering (C)
Menneskets lydopfattelse og audio teknik

Prerequisites:
Basic knowledge about electronic circuit theory one

Objective:
Students who complete the module:

Knowledge
- Must have knowledge about the anatomy and physiology of the human ear.
- Must have knowledge about hearing diagnosis and disorders
- Must have knowledge about fundamental properties of human sound perception (e.g. Loudness, pitch, masking, spatial hearing and time / frequency resolution)
- Basic knowledge in modern audio engineering including recording, reproduction and signal processing techniques (perceptive coding principles and formats, audio effects)
- Must have knowledge about multi-channel recording, storage and reproduction of sound
- Must have knowledge about public address techniques
- Must have insight in digital audio interfaces and standards
- Must have insight in low noise audio design and interconnections

Skills
- Must be able to set up audio systems for recording or reproduction in an appropriate way to optimize the system and minimize noise.
- Must be able to set up audio systems according to relevant standards

Competencies
- Based on the acquired knowledge, the student should be able to critically evaluate systems and specifications within audio and acoustics with a basis in human sound perception

Type of instruction:
As described in the introduction to Chapter 3.

Exam format:
Individual oral or written examination.

Evaluation criteria:
As stated in the Framework Provisions
Scientific Computing and Sensor Modeling (C)
Videnskabelige beregninger og sensor modellering

Prerequisites:
None

Objective:
Students who complete the module:

Knowledge
- Must have knowledge about hardware and software platforms for scientific computing.
- Must have knowledge about the possible speedup by using parallelization (Amdahl's 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.
- Must have knowledge about selected sensors and sensor signal processing devices and their basic working principle (examples of sensors: temperature, pressure, frequency, phase and position; examples of sensor signal processing devices: low noise amplifiers, power amplifiers, mixers and logical gates).
- Must have knowledge about how sensors and sensor signal processing devices can be modeled and how model parameters can be extracted from e.g. measurements or data sheets.
- Must have knowledge about how to simulate single and multiple connected sensors.

Skills
- Must be able to implement software programs to solve scientific computational problems using parallel computing.
- 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.
- Must be able to use sensor models in system simulations.

Competencies
- The student must be able to apply the proper terminology in oral and written communication and documentation within the scientific domains of scientific computing and sensor modeling.
- The student must be able to study and later understand and model sensors, which have not been treated in the course.

Type of instruction:
As described in the introduction to Chapter 3.

Exam format:
Individual oral or written examination.

Evaluation criteria:
As stated in the Framework Provisions
Audio Systems, Acoustics in Health Care, Development or Consultancy (P)
Audio systemer, akustik i sundhedssektoren, udvikling eller konsulent

Prerequisites:
Qualifications corresponding to having passed the 1st and 2nd semester.

Objective:
Students who complete the module:

Knowledge
- Must have knowledge about the principles and applications of audio systems in different environments.
- Must be able to design and implement engineering solutions to solve advanced acoustic problems arising in different acoustic environments.
- Must have knowledge about, and must be able to evaluate different acoustic environments with regards to their use and their effect on people.

Skills
- Must be able to determine the necessary requirements of audio systems, equipment or tools for a specific purpose.
- Must be able to design and evaluate existing audio systems, equipment or tools and their intended application.
- Must be able to evaluate auditory impact on people.
- Must be able to carry out advanced measurements according to relevant standards.

Competencies
- Must be able to identify and apply the adequate measurement and analysis tool for a given acoustic problem.
- Be able to quantify errors associated with different types of measurements and analysis methods and evaluate these methods regarding assumptions, simplifications and their application to the specific problem.
- Must be able to communicate the results of the project work in a project report
- Must be able to contribute successfully to teamwork within the problem area and make a common presentation of the result of the project work

Depending on the chosen focus area, the student should have competencies to apply knowledge and skills within one or more of the following work areas:

- Audio systems including e.g. public address systems, sound installations, recording and reproduction techniques, sound quality, theatre setups, HiFi, Musical acoustics and broadcasting
- Acoustics in health care including e.g. hearing diagnosis, perceptual investigations, sound quality, annoyance, hearing aids and psychological and physiological investigations
- Development including e.g. signal processing systems, audio platform development, loudspeakers, digital amplifiers, measurement systems, and hearing aids.
- Consultancy within e.g. noise, room acoustics, sound transmission in buildings, installation noise, room correction, legislation, recording studio design, outdoor sound propagation, traffic noise calculations, noise screens, and general calculation and prediction.

Type of instruction:
Project work.

Exam format:
Individual oral examination based on a written report.
Evaluation criteria:
As stated in the Framework Provisions
Applied Experimental Psychology and Psychophysics  
Anvendt eksperimentalpsykologi og psykofysik

Prerequisites:  
Basic statistics and probability theory

Objective:  
Students who complete the module:

Knowledge  
Must have knowledge of the psychophysical methods that can be used to measure human perception, cognition, and performance, including:

- Threshold and comparison methods
- Quantitative methods for measuring psychophysical responses including, nominal, ordinal, interval and ratio scales.
- Transformation of data to relevant scales. Normalization and standardization.
- Comparative and non-comparative scaling: paired comparison and semantic differential techniques.
- Probabilistic choice models for paired comparison (BTL), and the concept of transitivity.
- Descriptive analysis, including selection and use of censor panels for scaling experiments, word elicitation, selection, scaling and analysis.
- Practical design of scales.
- Design of scaling experiments.
- Factor analysis.

Skills  
The students must be able to:
- Carry out measurement and scaling of psychophysical responses.
- Use statistical software for analysis of the results

Competencies  
- Can choose the appropriate psychophysical method for a given problem.
- Have experience carrying out experiments using appropriate methods.
- Can analyze the results from experiments using appropriate statistical methods.

Type of instruction:  
Lectures followed by exercises and lab-work.

Exam format:  
Individual oral or written examination.

Evaluation criteria:  
As stated in the Framework Provisions
Array and Sensor Signal Processing (C)
Array- og sensor signalbehandling

Prerequisites:
Stochastic processes, basic estimation theory, and optimization methods.

Objective:
Students who complete the module:

Knowledge
- Must have knowledge about the Cramér-Rao lower bound (CRLB) as well as (asymptotic) optimal unbiased estimators such as minimum variance unbiased estimator, maximum likelihood, and least-squares.
- Must have knowledge about 1- and 2-dimensional spectral estimation methods such as the period gram, the Yule-Walker equations, subspace-based methods (MUSIC and ESPRIT), and filter-bank methods (Capon’s method and Amplitude and Phase ES estimation (APES)).
- Must have knowledge about fundamental terms and methods applied for design and analysis of adaptive filter such as Steepest descent, least-mean-square (LMS), normalized LMS (NLMS), affine projections (AP), recursive least-squares (RLS), transient and steady-state performance.
- Must have knowledge about terms and methods applied for design and analysis of multi-rate signal processing systems, such as Hilbert transform, Noble identities, poly-phase decomposition, commutators, re-sampling, as well as up- and down-sampling.

Skills
- Must be able to compare the estimation performance of unbiased estimators by using the CRLB.
- Must be able to apply methods and algorithms for parametric and non-parametric spectral estimation on 1- and 2-dimensional signals.
- Must be able to implement fundamental adaptive filters such as the (normalized) least-mean-square filter, the affine projection filter, and the recursive least-squares filter.
- Must be able to apply fundamental methods for analysis, design, and implementation of poly-phase filters.

Competencies
- Must have competencies in analyzing a given problem which in its solution requires advanced signal processing methodologies and next identify appropriate methods and algorithms to solve the problem.
- Must have competencies in understanding the strengths and weaknesses of the methods.

Type of instruction:
As described in the introduction to Chapter 3.

Exam format:
Individual oral or written examination.

Evaluation criteria:
As stated in the Framework Provisions
User Experience Design for Multi-modal Interaction (C)
Design af brugeroplevelsen for multi modal interaktion

Prerequisites:
Basic knowledge in interaction design and usability.

Objective:
This course trains students to research, analyze, prototype, and conceptualize design considering all system aspects including the social and cultural contexts of use. The course gives a comprehensive knowledge about user involvement in the design process going beyond traditional methods such as usability lab testing.

The objectives are realized by presenting methods and tools in a case based framework and through the students’ active participation in workshops and assignments.

Students who complete the module:

Knowledge
- Must have knowledge about system design methods including the social and cultural contexts of use.
- Must have knowledge derived from sociological and ethnographic fields for user behavior research
- Must have knowledge about qualitative research methods involving end users in the field, such as interview techniques and analysis and experience sampling
- Must have knowledge about scenario-based design methods
- Must have knowledge about principles for multi modal interaction design
- Must have knowledge about methods for multi modal evaluation and field studies

Skills
- Must be able to apply the taught methods to solve concrete design problems.
- Must be able to evaluate and compare and apply the methods for a specific design problem
- Must be able to facilitate the design process involving users in real-life contexts

Competencies
- Students will acquire the competencies to decide how to choose the appropriate method to suit different dimensions of a design problem at different stages in the process and the pitfalls of each approach
- Must have competencies in understanding the strengths and weaknesses of the methods
- Must have the competencies to facilitate the design process involving users in context

Type of instruction:
As described in the introduction to Chapter 3.

Exam format:
Individual oral or written examination.

Evaluation criteria:
As stated in the Framework Provisions
Platforms and Methods for Multi Modal System Architectures (C)
Platforme og metoder til multi modale system arkitekturer

Prerequisites:
Basic knowledge in human-computer interaction and software design.

Objective:
The course will enable the student to understand the principles of multi modal user interaction, including speech based interaction and computer vision, and to extend the methods for HCI GUI design to analyze, design and synthesize multi modal user interaction

Students who complete the module:

Knowledge
- Must have knowledge about integration of sensory information from non-standard signal sources.
- Must have knowledge about methods and architectures for fusion of multi modal information from e.g. speech, gaze, sound and gesture modalities.
- Must have knowledge about context-aware multimodal interaction.

Skills
- Must be able to apply the taught platforms and methods to analyze and design multi modal user interfaces.
- Must be able to evaluate and compare interaction modalities relevant to a specific application.

Competencies
- Must have competencies in analyzing a given problem and identifying appropriate modalities and their fusion to the problem.
- Must have competencies in understanding the pros and cons of the modalities of relevance

Type of instruction:
As described in the introduction to Chapter 3.

Exam format:
Individual oral or written examination.

Evaluation criteria:
As stated in the Framework Provisions
Prerequisites:
Passed three previous semester or alike

Objective:
Students who complete the module:

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

Skills
- are able to reflect on a scientific basis on their knowledge,
- can argue for the relevance of the chosen problem to the education including specifically account for the core of the problem and the technical connections in which it appears
- can account for possible methods to solve the problem statements of the project, describe and assess the applicability of the chosen method including account for the chosen delimitation and the way these will influence on the results of the product
- can analyze and describe the chosen problem applying relevant theories, methods and experimental data
- are able to describe the relevant theories and methods in a way that highlights the characteristics and hereby document knowledge of the applied theories, methods, possibilities and delimitations within the relevant problem area
- have the ability to analyze and assess experimental data, including the effect the assessment method has on the validity of the results.

Competencies
- are able to communicate scientific problems in writing and orally to specialist and non-specialist.
- are able to control situations that are complex, unpredictable and which require new solutions,
- 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.

If the project is carried out as a long master's thesis the learning objectives include those defined for the 3rd semester of the education.

Type of instruction:
As described in the introduction to Chapter 3.

Exam format:
Individual oral examination based on a written report.

Evaluation criteria:
As stated in the Framework Provisions
Chapter 4: Entry into Force, Interim Provisions and Revision

The curriculum is approved by the Dean of the Faculty of Engineering and Science.

Students who wish to complete their studies under the previous curriculum from 2008 must conclude their education by the summer examination period 2012 at the latest, since examinations under the previous curriculum are not offered after this time.

In accordance with the Framework Provisions for the Faculty of Engineering and Science and The Faculty of Medicine at Aalborg University, the curriculum 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 Master's thesis
In the assessment of all written work, regardless of the language it is written in, weight is also given to the student's spelling and formulation ability, in addition to the academic content. Orthographic and grammatical correctness as well as stylistic proficiency are taken as a basis for 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 Master’s thesis must include an English summary. If the project is written in English, the summary must be in Danish. The summary must be at least 1 page and not more than 2 pages. 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 the 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 by the Board of Studies based on an academic assessment. See the Framework Provisions for the rules on credit transfer.

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

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

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1 Or another foreign language (upon approval from the Board of Studies.
2 The Board of Studies can grant exemption from this.
5.5 Completion of the Master’s programme
The Master’s programme must be completed no later than four years after it was begun.

5.6 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.

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