



# Curriculum for Master of Science in Sound and Music Computing

Aalborg University  
September 2014

## Preface:

Pursuant to Act 367 of March 25, 2013 on Universities (the University Act) with subsequent changes, the following curriculum for the Master's programme in Medialogy is stipulated. The programme also follows the Framework Provisions and the Examination Policies and Procedures for the Faculties of Engineering and Science.

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## ***Chapter 1: Legal Basis of the Curriculum, etc.***

### **1.1 Basis in ministerial orders**

The Master's programme in Sound and Music Computing is organised in accordance with the Ministry of Science, Technology and Innovation's Ministerial Order no. 1520 of December 16, 2013 on Bachelor's and Master's Programmes at Universities (the Ministerial Order of the Study Programmes) and Ministerial Order no. 1518 of December 16, 2013 on University Examinations (the Examination Order) with subsequent changes. Further reference is made to Ministerial Order no. 1488 of December 16, 2013 (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 Faculties of Engineering and Science, Aalborg University.

### **1.3 Board of Studies affiliation**

The Master's programme falls under the Board of Studies for Media Technology.

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

### **2.1 Admission**

Admission to the Master's programme in Sound and Music Computing requires a Bachelor's degree in computer science, engineering, Medialogy or equivalent.

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 following designation:

Civilingeniør, Cand.polyt. i lyd- og musikteknologi. The English designation is: Master of Science (MSc) in Engineering (Sound and Music Computing).

### **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 mission of the SMC Master is to train the professionals that will push forward the sound and music technologies of the new information society. By combining practical and theoretical approaches in topics such as computational modeling, audio engineering, perception, cognition, and interactive systems, the program gives the scientific and technological background needed to start a research or professional career. This program trains the students on the technologies for the analysis, description, synthesis, transformation and production of sound and music, and on the technologies and processes that support sound and music creation.

### The graduate of the Master's programme:

- |              |  |
|--------------|--|
| Knowledge    | <ul style="list-style-type: none"><li>• has in-depth <b>knowledge</b> and understanding of issues within the areas of sound and music technology and design.</li><li>• can <b>understand</b> and, on a scientific basis, reflect on the technical, organizational and market drivers in sound and music technology as well as the interplay between technology, market and user issues</li><li>• can <b>analyze</b> sound and music computing's knowledge, theory, methodologies and practice, and identify scientific issues</li></ul>  |
| Skills       | <ul style="list-style-type: none"><li>• ability to <b>synthesize</b> scientific methods, tools and general skills within the field of sound and music computing.</li><li>• ability to <b>evaluate</b> and select among relevant scientific theories, methods, tools and general skills and, on a scientific basis, advance new analyses and solutions within the subject areas</li><li>• ability to <b>synthesize</b> research-based knowledge and discuss professional and scientific problems with both peers and non-specialists</li><li>• ability to <b>synthesize</b> knowledge in scientific writing: articles, reports, documentation, etc.</li><li>• ability to <b>analyze</b> and select among relevant theories, technologies and methods for development of sound and music technology solutions and services</li><li>• can <b>analyze</b> different technologies for optimal selection</li><li>• can <b>analyze</b> the research potential or the market, ethical and regulatory framework for application of the technologies</li></ul>   |
| Competencies | <ul style="list-style-type: none"><li>• ability to <b>apply</b> acquired knowledge in research, innovation and entrepreneurship that can be used to explore and exploit the great potential of new media technologies with an engineering approach</li><li>• ability to <b>synthesize</b> acquired knowledge creatively and innovatively to identify and propose new opportunities and develop services/solutions, which can empower the users and assist them in solving their current and future tasks on a daily basis</li><li>• ability to <b>synthesize</b> project work and problem based learning in a global/multicultural environment</li><li>• ability to <b>apply</b> knowledge to independently initiate and implement discipline-specific and interdisciplinary cooperation and assume professional responsibility</li><li>• ability to <b>synthesize</b> knowledge and independently take responsibility for own professional development and specialization</li><li>• <b>apply</b> acquired knowledge in mediating collaborations and exchange between development- and business-related functions in organizations</li></ul> |

## **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 specific exam periods. Examinations are defined in the curriculum. Each semester has an overall theme, which is reflected in the scope of the (mandatory) course modules and semester projects.

The programme is based on a 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

### **3.1 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 or course-responsible only.

An overview of the ECTS credit breakdown for the various semesters by modules is shown in the table form below.

In general, students may choose different options for the 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> semester. The thesis project must have a size of at least 30 ECTS, but it is possible to make larger thesis projects of 35, 40, 45, 50, 55 or 60 ECTS, if the thesis project is initiated in the 3<sup>rd</sup> semester. Depending on the choice, there will be room for 2-3 elective courses on the 3<sup>rd</sup> semester. The following options may be chosen:

#### **Option 1:**

- 3rd semester: 15 ECTS semester project, supplemented by courses
- 4th semester: 30 ECTS thesis project

#### **Option 2:**

- 3rd semester: internship in Denmark or abroad, or exchange in Denmark or abroad (in this case the mandatory courses on the 3<sup>rd</sup> semester may be waived)
- 4th semester: 30 ECTS thesis project

#### **Option 3 (long thesis project):**

- A thesis project of 35, 40, 45, 50, 55 or 60 ECTS, extending over 2 semesters, if necessary supplemented by courses on the 3<sup>rd</sup> semester in order to achieve the required number of ECTS.

### 3.2 Courses

Semester	Module	ECTS	Assessment	
1st	Foundations of SMC	15	7-point scale	Internal
	Sound Processing	5	7-point scale	Internal
	Multivariate Statistics and Pattern Recognition	5	7-point scale	Internal
2nd	Music Perception and Cognition	5	7-point scale	Internal
	Realtime Interaction and Performance	5	7-point scale	Internal
	Sound and Music Signal Analysis	5	7-point scale	Internal
	<b>Choose 1 from the following:</b>			
	Music Information Research	15	7-point scale	External
3 <sup>rd</sup>	Sonic Interaction Research	15	7-point scale	External
	<b>Choose 1 from the following:</b>			
	Multimedia programming	5	Pass/Fail	Internal
	Modelling physical systems	5	Pass/Fail	Internal
	Human Sound Perception and Audio Engineering <sup>1</sup>	5	Pass/Fail	Internal
	Sound and Music Innovation	15	7-point scale	Internal
3 <sup>rd</sup>	Research in Sound and Music Computing	5	7-point scale	Internal
	<b>Choose 2 from the following:</b>			
	Multimodal Perception and Cognition	5	7-point scale	Internal
	Prototyping and Fabrication Techniques	5	Pass/Fail	Internal
	Applied Experimental Psychology and psychophysics <sup>2</sup>	5	Pass/Fail	Internal
4 <sup>th</sup>	Master's Thesis	30	7-point scale	External

<sup>1</sup> See course description in the curriculum for Master of Science (MSc) in Engineering (Acoustics and Audio Technology) at <http://www.en.sict.aau.dk/Current+Students/Study+Curricula/Electronics+and+IT/>

<sup>2</sup> See course description in the curriculum for Master of Science (MSc) in Engineering (Acoustics and Audio Technology) at <http://www.en.sict.aau.dk/Current+Students/Study+Curricula/Electronics+and+IT/>

Semester project

**Foundations of SMC**

(Grundlæggende lyd- or musikteknologi)

Workload: 15 ECTS, consisting of project work

Semester: 1st semester

**Prerequisites:** Bsc in Computer Science, Engineering, Medialogy or equivalent

**Objectives:**

Investigate sound and music computing from a formal perspective, with a focus on the following: 1) constructing an application related to sound processing or 2) constructing and application related to new interfaces for musical expression, 3) a combination of 1) and 2).

Additionally, students are required to work according to a scientific method and to report results in scientific forms, such as papers and posters.

Students who complete the module will gain knowledge, skills and competences as follows:

**Knowledge:**

- Must be able to understand the core elements in sound processing, either considering sound as input modality (machine listening, such as segmentation and feature extraction, modeling and prediction, coding and classification, etc.) or output modality (sonic interaction design, new interfaces for musical expression).
- Must be able to understand principles of real-time sound processing.

**Skills:**

- Must be able to **apply** a sound engine, to design and implement a system which uses sound as input or output modality

**Competencies**

- Must be able to **synthesize** relevant theory, techniques and tools to produce new knowledge and/or solutions
- Must be able to **synthesize** and discuss research-based knowledge in the area of sound and music computing, in the formats of a scientific paper and a poster, and in the format of a 15 minute conference presentation

**Type of instruction:**

Academically supervised student-governed problem oriented project work

**Exam format:**

In accordance with the current Framework Provisions and directions on examination from the Study Board for Media Technology:

Oral exam with an internal censor based on a scientific paper written in English and a media-technological product, an AVproduction illustrating and summarizing the project, a poster in English, and edited worksheets/portfolio documenting project details.

The assessment is performed in accordance with the 7-point grading scale.

**Evaluation criteria:** The criteria for the evaluation are specified in the Framework Provisions.

<p><b>Title:</b>  <b>Sound Processing</b>  (Lydprocessering)</p>
<p><b>Size:</b> 5 ECTS</p>
<p><b>Prerequisites:</b></p>
<p><b>Objectives:</b>  This class introduces sound technology from the viewpoint of sound synthesis and digital audio effects. The proper application and development of such systems requires competencies in the acquisition and manipulation of sounds.</p> <p>Students who complete the course module will obtain the following qualifications:</p> <p style="text-align: center;"><b>Knowledge</b></p> <ul style="list-style-type: none"> <li>• <b>Understand</b> the application of transforms to analyze signals and systems</li> <li>• <b>Understand</b> digital sampling, quantization, and reconstruction of audio signals, and the variety of technical specifications that accompany such systems, e.g., sampling rate, bit rate, quantization resolution, etc.</li> <li>• <b>Understand</b> filter implementations (IIR, FIR, forms) and their differences</li> <li>• <b>Understand</b> delay lines and delay based effects (flangers, vibrato, chorus, echo)</li> <li>• <b>Understanding</b> modulators and demodulators</li> <li>• <b>Understanding</b> spatial effects</li> </ul> <p style="text-align: center;"><b>Skills</b></p> <ul style="list-style-type: none"> <li>• <b>Implement</b> and <b>apply</b> filters to sound and music signals and <b>evaluate</b> the results</li> <li>• <b>Apply</b> knowledge to the design of digital audio effects.</li> </ul> <p style="text-align: center;"><b>Competencies</b></p> <ul style="list-style-type: none"> <li>• <b>Apply</b> appropriate methods and tools to <b>analyze</b> a sampled audio signal and <b>evaluate</b> with a high level of detail the content represented in the data</li> <li>• <b>Apply</b> appropriate methods and tools to <b>analyze</b> a digital system and <b>evaluate</b> with a high level of detail how it affects sampled audio data passed through it</li> </ul>
<p><b>Type of instruction:</b>  Lectures and laboratories. There is no project associated with this course.</p>
<p><b>Exam format:</b>  In accordance with the current Framework Provisions and directions on examination from the Study Board for Media Technology: Oral examination comprising examination in a) theoretical parts (lectures) and b) practical part (laboratories), grading according to the 7-point scale with internal censor.</p>
<p><b>Evaluation criteria:</b> The criteria for the evaluation are specified in the Framework Provisions.</p>

<p><b>Title:</b>  <b>Music Perception and Cognition</b>  (Musikperception og –kognition)</p>
<p><b>Size:</b> 5 ECTS</p>
<p><b>Prerequisites:</b> BSc in Medialogy or equivalent, basic knowledge of music theory, basic programming skills, basic understanding of scientific methodology</p>
<p><b>Objectives:</b></p> <p>Musical information is created, communicated and processed in a wide variety of contexts and activities. Humans engage with music passively (e.g., when listening), actively (e.g., when composing) and interactively (e.g., when improvising or performing with others). Musical information may encode musical sound, perceived musical structure, the affective or semantic content of music, musical gestures or musical interactions. The ability to design and build effective and efficient computing systems for processing musical information requires an understanding of how such information is created, represented, communicated and processed by humans.</p> <p>This course introduces experimental, theoretical, computational and neuroscientific work that has contributed to our understanding of how musical information is created, represented, communicated and processed, both in the brain and the body, when humans perform musical tasks such as listening, dancing, performing, composing and improvising.</p> <p>Students who complete this course must gain the following knowledge, skills and competencies.</p> <p style="text-align: center;"><b>Knowledge</b></p> <ul style="list-style-type: none"> <li>● Must <b>understand</b> the basic principles underlying the perception and cognition of the main types of musical structure (including melodic, harmonic, motivic, tonal and rhythmic structure as well as the role of auditory streaming in music).</li> <li>● Must <b>understand</b> the basic cognitive and motoric mechanisms underlying expressive human performance (for example, in relation to timing and dynamics).</li> <li>● Must have <b>knowledge</b> about musicians' interactions (with instruments, audience, and co-performers).</li> <li>● Must <b>understand</b> current theories of how emotion (affect) is represented and communicated by music.</li> <li>● Must <b>understand</b> current theories of the relationship between music and movement (embodied music cognition).</li> <li>● Must <b>understand</b> current theories of how musical skills and knowledge are learnt and then applied in creative tasks such as composition and improvisation.</li> </ul>

### Skills

- Must be able to **apply** understanding of experimental methodologies in the design and execution of appropriate experiments for testing hypotheses in the field of music perception and cognition.
- Must be able to **create** and **test** basic computational models of specific aspects of music perception and cognition (e.g., perception of musical streams, expressive timing).
- Must be able to **evaluate** theories and models of music perception and cognition.

### Competencies

- Must be able to **apply** and **synthesize** understanding of experimental, computational, theoretical and neuroscientific research on music perception and cognition in the design and testing of music computing systems.
- Must be able to **apply** and **synthesize** understanding of experimental and theoretical work in music perception and cognition to the design, execution and analysis of appropriate experiments.
- Must be able to **evaluate** current experimental, theoretical and computational research in music perception and cognition.

#### **Type of instruction:**

Refer to the overview of instruction types listed in the start of chapter 3. The types of instruction for this course are decided in accordance with the current Framework Provisions and directions are decided and given by the Study Board for Media Technology.

#### **Exam format:**

In accordance with the current Framework Provisions and directions on examination from the Study Board for Media Technology: Oral or written examination with internal censor. The assessment is performed in accordance with the 7-point grading scale.

**Evaluation criteria:** The criteria for the evaluation are specified in the Framework Provisions.

<p><b>Title:</b>  <b>Multivariate Statistics and Pattern Recognition</b>  (Multivariat statistik og mønstergenkendelse)</p>
<p><b>Size:</b> 5 ECTS</p>
<p><b>Prerequisites:</b> BSc in Medialogy or equivalent</p>
<p><b>Objectives:</b>  When designing and developing interactive media systems and technology, one is often faced with looking for interesting patterns and trends in data of several dimensions, what is called 'multivariate data.' This course presents theoretical concepts and practical tools for analyzing multivariate data and designing pattern recognition methods for multimedia applications. Many of these methods are used in, e.g., automatic speech recognition, face detection, web page ranking, etc. The course includes the following topics: multivariate probability density functions, Bayesian estimation and detection, Gaussian model, parameter estimation, assessment of classifiers and estimators, data fitting, supervised and unsupervised learning, parametric and non-parametric learning, feature selection and reduction, and clustering.</p> <p>Students who complete the course module will obtain the following qualifications:</p> <p><b>Knowledge:</b></p> <ul style="list-style-type: none"> <li>• <b>Understand</b> multivariate statistics and describe how to model multivariate data, e.g., using probabilistic and parametric descriptions</li> <li>• <b>Understand</b> Bayesian classification</li> <li>• <b>Understand</b> supervised and non-supervised learning methods, e.g., k-means clustering, principal component analysis, nearest neighbor</li> <li>• <b>Understand</b> features and the process of feature extraction from data</li> </ul> <p><b>Skills:</b></p> <ul style="list-style-type: none"> <li>• Choose, implement and <b>apply</b> pattern recognition tools to solve classification problems, e.g., footstep detection from accelerometers, recognition of single spoken digits</li> <li>• <b>Apply</b> knowledge to compare classification methods in terms of performance and complexity</li> <li>• <b>Apply</b> theory of multivariate statistics and <b>analyze</b> multimedia data, e.g., speech and music, images of faces, etc.</li> </ul> <p><b>Competencies:</b></p> <ul style="list-style-type: none"> <li>• <b>Analyze</b> a problem in your field in the context of multivariate statistics and pattern recognition, and reflect on a variety of possibilities to recommend a solution</li> <li>• <b>Analyze</b> features for this problem  Implement and <b>evaluate</b> a classifier for this problem, and discuss and generalize the results</li> </ul>
<p><b>Type of instruction:</b>  Refer to the overview of instruction types listed in the start of chapter 3. The types of instruction for this course are decided in accordance with the current Framework Provisions and directions are</p>

decided and given by the Study Board for Media Technology.

**Exam format:**

In accordance with the current Framework Provisions and directions on examination from the Study Board for Media Technology:

Oral or written examination with internal censor. The assessment is performed in accordance with the 7-point scale.

**Evaluation criteria:** The criteria for the evaluation are specified in the Framework Provisions.

Semester project:  
**Sonic Interaction Research**  
(Sonisk interaktion)

Workload: 15 ECTS, consisting of project work  
Semester: 2nd semester

**Prerequisites:**  
1<sup>st</sup> semester of SMC Master or similar

**Objectives:**

Explore the field of sonic interaction design with a focus on one of the following applications: 1) Interactive product sound design, 2) sonic interactions in arts, 3) interactive sonification. Perform an evaluation of the perceptual and/or cognitive aspects of sonic interactions from a human centered perspective.

Students who complete the module will gain knowledge, skills and competences as follows:

**Knowledge**

- Must be able to **understand** the discipline of sonic interaction design.
- Must be able to **understand** theories behind the generation of sonic interactions.
- Must be able to **understand** the discipline of interactive sonification., understood as the ability to use sound to provide information.
- Must be able to **understand** principles of music perception, cognition and action.

**Skills**

- Must be able to **apply** the acquired knowledge to the design of an application where interactive sound plays a salient role, being either in an artistic context, in the field of interactive product sound design or in the field of interactive sonification.
- Must be able to **apply** knowledge in human sound perception and cognition to the evaluation of the proposed solution.

**Competencies**

- Must be able to **evaluate** the proposed application from a human centered perspective, and synthesize it to produce new knowledge and solutions.

**Type of instruction:**

Academically supervised student-governed problem oriented project work.

**Exam format:** In accordance with the current Framework Provisions and directions on examination from the Study Board for Media Technology:

Oral examination with external censor based on a written project report and a media-technological product plus an A/V production that illustrates and summarizes the project.

The assessment is performed in accordance with the 7-point grading scale.

<p><b>Evaluation criteria:</b> The criteria for the evaluation are specified in the Framework Provisions.</p>
<p>Semester project:  <b>Music Information Research</b>  (Informationsøgning i musik)</p> <p>Workload: 15 ECTS, consisting of project work  Semester: 2nd semester</p>
<p><b>Prerequisites:</b>  1<sup>st</sup> semester of SMC Master or similar</p>
<p><b>Objectives:</b>  Explore the development and analysis of practical and automatic methods for making accessible information contained in abstract formats of music, such as symbolic (sheet music), or digital audio samples (MP3), i.e., all the information that currently requires experienced human to extract. These include various tasks in which one can analyze music signals for, e.g., inferring or identifying the artist and song playing in a noisy environment like a pub (c.f. Shazam), organizing a music collection by genres (e.g., blues and/or hip hop), mood (e.g., restful or excited), or use (e.g., relaxation or exercise), determining the instruments playing in a recording (e.g., guitar and gong), the recording type (e.g., live or studio), (un)recommending music (e.g., “if you like Gustav Winckler, then you will not like L.O.C.”), creating playlists (e.g., “suggest a mix of songs from my collection for my new girlfriend”), composing new music (e.g., “mash together this Gustav Winckler song and that L.O.C. song”), automatic mastering (e.g., “what changes do I need to make to my song to make it more Pop-sounding?”), and so on.</p> <p>Students who complete the module will gain knowledge, skills and competences as follows:</p> <p style="margin-left: 40px;"><b>Knowledge</b></p> <ul style="list-style-type: none"> <li>• Must be able to <b>describe</b> and <b>distinguish</b> between methods of content classification, retrieval and description for audio and music signals</li> <li>• Must be able to <b>describe</b> the structure of systems for audio or music classification, retrieval, and description</li> <li>• Must be able to <b>distinguish</b> between supervised and unsupervised learning, and how they are used in music information research</li> <li>• Must be able to <b>identify</b> and <b>describe</b> low-, mid- and high-level representations of sound and music, and how they are used in music information research</li> <li>• Must be able to <b>summarize</b> the importance and relevance of human perception for music information research</li> <li>• Must be able to <b>summarize</b> and <b>distinguish</b> the experimental designs and figure of merits to use in music information research</li> </ul> <p style="margin-left: 40px;"><b>Skills</b></p> <ul style="list-style-type: none"> <li>• Must be able to <b>analyze</b> and <b>compare</b> a variety of approaches to audio and music content classification, retrieval, and description</li> <li>• Must be able to <b>explain</b> and <b>compare</b> a variety of approaches to evaluating systems for audio and music content classification, retrieval, and description</li> <li>• Must be able to <b>explain</b> the concepts behind a complex integrated system for working with the contents of audio and/or music signals, e.g., a sound search engine, query-by-humming or –example, music</li> </ul>

identification through fingerprint comparison, speech-driven menu system, and so on

- Must be able to **analyze** the approaches and algorithms applied in a piece of scientific literature in music information research, interpret the assumptions made, and relate them to the goals of the work
- Must be able to **implement** and reproduce a piece of scientific research literature in music information research, **interpret** the results, and **compare** them with those of the original research
- Must be able to **explain** and **argue** for all assumptions made in the re-implementation

#### **Competencies**

- Must be able to **evaluate** and **criticize** within the format of a critical annotation a recent piece of scientific literature (journal articles and conference papers) related to music information research (identifying its relevance and the perspective of the authors, stating the scientific hypothesis, theory, approaches and solutions, assumptions made, and its conclusions and contributions)
- Must be able to **discuss** and **evaluate** a complex integrated system for working with the contents of audio and/or music signals, e.g., a sound or music search engine, query-by-humming or –example, music identification through fingerprinting, recommender systems, and so on
- Must be able to **choose** and **judge** frameworks for music information retrieval in a variety of practical situations

#### **Type of instruction:**

Academically supervised student-governed problem oriented project work.

**Exam format:** In accordance with the current Framework Provisions and directions on examination from the Study Board for Media Technology:

Oral examination with external censor based on a written project report and a media-technological product plus an A/V production that illustrates and summarizes the project.

The assessment is performed in accordance with the 7-point grading scale.

**Evaluation criteria:** The criteria for the evaluation are specified in the Framework Provisions.

<p><b>Title:</b>  <b>Realtime Interaction and Performance</b>  (Realtidsinteraktion og –udførelse)</p>
<p><b>Size:</b> 5 ECTS</p>
<p><b>Prerequisites:</b></p>
<p><b>Objectives:</b>  This module focuses on the study of real-time interaction from several perspectives, both conceptual and technological.</p> <p>The conceptual part starts discussing the concept of real-time focusing on real-time musical interaction because, for millennia, musical performance has constituted the paradigm of rich and complex real-time human-machine-interaction. From this musical perspective the concepts of 'controller device' and 'mapping' are studied in depth. The musical context is a core focus in the class, including studying expert interaction, analyzing concepts such as playability, explorability, non-linearity, control, expressiveness or virtuosic interaction.</p> <p>The technological part of the course starts by defining and studying the more important technical concepts and aspects of real-time interaction and implementations. After that, different programming languages paradigms and different real-time communication protocols between applications are studied.</p> <p style="text-align: center;"><b>Knowledge</b></p> <ul style="list-style-type: none"> <li>• <b>Understand</b> the concept of real-time interaction</li> <li>• <b>Knowledge</b> on the history and taxonomical study of musical instruments</li> <li>• <b>Understanding</b> the concept of musical controller, mapping and feedback</li> <li>• <b>Understanding</b> realtime human-computer interaction in a musical performance perspective.</li> <li>• <b>Understanding</b> protocols for realtime communication in musical performance</li> </ul> <p style="text-align: center;"><b>Skills</b></p> <ul style="list-style-type: none"> <li>• <b>Apply</b> knowledge to the design of an interface for musical expression.</li> </ul> <p style="text-align: center;"><b>Competencies</b></p> <ul style="list-style-type: none"> <li>• <b>Apply</b> appropriate methods and theories for realtime interaction to the design of a novel interface for musical expression.</li> </ul>
<p><b>Type of instruction:</b>  Lectures and laboratories. There is no project associated with this course.</p>
<p><b>Exam format:</b>  In accordance with the current Framework Provisions and directions on examination from the Study Board for Media Technology: Oral examination comprising examination in a) theoretical parts (lectures) and b) practical part (laboratories), grading according to the 7-point scale with internal censor.</p>
<p><b>Evaluation criteria:</b> The criteria for the evaluation are specified in the Framework Provisions.</p>

**Title:****Sound and Music Signal Analysis**

(Analyse af lyd- og musiksignaler)

**Size:** 5 ECTS**Objectives:**

The course introduces the fundamentals sound and music analysis: 1) methods required to perform analysis of sound and music signals; 2) representations commonly used in sound and music analysis; 3) various analysis tasks involving sound and music representations. The first part focuses on the basic methods, e.g., spectral analysis, parameter estimation, audio decomposition methods, filterbanks, etc. The second part includes commonly used representations for characterizing sound and music signals, e.g., parametric models, spectrograms, mel-frequency cepstral coefficients, chromagrams, and source-filter models. The third part focuses on examples of sound and music analysis tasks, e.g., tuning of musical instruments, transcription of music, key and chord detection, and modification of sound and music signals.

Students who complete the course module will obtain the following qualifications:

**Knowledge**

- Must be able to **understand** and **describe** spectral analysis, parameter estimation, methods for audio decompositions, and filterbanks.
- Must be able to **understand** the assumptions upon which various methods and representations are based.
- Must be able to **distinguish** between pitch, loudness and timbre, and **explain** how these relate to the various representations.
- Must be able to **understand** and **identify** how audio analysis tasks relate to human sound perception, and characteristics of music and sound.

**Skills**

- Must be able to **analyze** and **explain** the tools and representation used for a given sound and music analysis task.
- Must be able to **select, implement** and **apply** selected methods for analysis of sound and music signals.
- Must be able to **evaluate** the performance and properties of the selected methods and representations for sound and music analysis.
- Must be able to **explain** and **argue** for the assumptions made when using particular tools and representations for sound and music analysis.

**Competences**

- Must be able to **understand** and **evaluate** research in the area of sound and music signal analysis.
- Must be able to **discuss** and **evaluate** the appropriateness of various representations for a given sound and musical analysis task.
- Must be able to **choose** between and **judge** methods and representations for sound and music analysis.

**Type of instruction:**

Lectures with exercises, and individual 2 ECTS project.

**Exam format:**

In accordance with the current Framework Provisions and directions on examination from the Study Board for Media Technology: Oral or written examination with internal censor, grading according to the 7-point scale.

**Evaluation criteria:** The criteria for the evaluation are specified in the Framework Provisions.

<p><b>Title:</b>  <b>Multimedia Programming</b>  (Multimedieprogramming)</p>
<p><b>Size:</b> 5 ECTS</p>
<p><b>Prerequisites:</b>  1<sup>st</sup> semester or equivalent</p>
<p><b>Objectives:</b>  The goal of this course is to strengthen a student's capacity to participate in software development. This puts the student in a position to take advantage of a significant amount of prior work by integrating a variety of software libraries on a variety of platforms.</p> <p>Students who complete the module will gain knowledge, skills and competences as follows:</p> <p><b>Knowledge:</b></p> <ul style="list-style-type: none"> <li>• <b>Understand</b> advanced topics of software development relevant to the design and implementation of multimedia software applications, e.g., software design patterns, multi-threaded programming, real-time programming, advanced UML, GPU programming, programming mobile devices and other embedded systems, network programming, graphics, VR and AR programming</li> </ul> <p><b>Skills:</b></p> <ul style="list-style-type: none"> <li>• ability to <b>apply</b> a variety of intermediate and advanced software technologies, techniques and methods in the construction of effective and efficient multimedia software applications</li> </ul> <p><b>Competencies:</b></p> <ul style="list-style-type: none"> <li>• ability to <b>analyze</b> multimedia software engineering problems and select, <b>apply</b> and <b>evaluate</b> appropriate technologies in developing successful solutions</li> <li>• ability to <b>synthesize</b> advanced concepts in multimedia programming and software engineering</li> </ul>
<p><b>Type of instruction:</b> Refer to the overview of instruction types listed in the start of chapter 3. The types of instruction for this course are decided in accordance with the current Framework Provisions and directions are decided and given by the Study Board for Media Technology.</p>
<p><b>Exam format:</b> In accordance with the current Framework Provisions and directions on examination from the Study Board for Media Technology:  Individual oral or written examination with internal censor. The assessment is performed with the Pass/Non-Pass grade.</p>
<p><b>Evaluation criteria:</b> The criteria for the evaluation are specified in the Framework Provisions.</p>

<p><b>Title:</b>  <b>Modelling Physical Systems</b>          (Modellering af fysiske systemer)</p>
<p><b>Size:</b> 5 ECTS</p>
<p><b>Prerequisites:</b>          Basic knowledge in Programming and Prototype development.</p>
<p><b>Objectives:</b>          The module gives an in-depth introduction to modelling of physical systems and the analogies between dynamics systems such as mechanical, hydraulic, electronic, and acoustic systems. Constructing and modelling physical systems requires an understanding of basic kinematics and kinetics. In turn, models of dynamic systems have analogies that can be described by the same underlying mathematics. Students who complete this module will understand the basics of mechatronic systems and the analogy between various dynamic systems.</p> <p>Students who complete the module will gain knowledge, skills and competences as follows:</p> <p><b>Knowledge</b></p> <ul style="list-style-type: none"> <li>• Must have <b>knowledge</b> about the kinematics of particles</li> <li>• Must have <b>knowledge</b> about the kinetics of particles</li> <li>• Must be able to <b>understand</b> the analogy between various dynamic systems, i.e. electronic, mechanical and hydraulic systems</li> <li>• Must be able to <b>understand</b> how to model the kinematics and kinetics of simple mechanical systems</li> </ul> <p><b>Skills</b></p> <ul style="list-style-type: none"> <li>• Must be able to <b>apply</b> knowledge to the creation of free body diagrams of dynamic systems</li> <li>• Must be able to <b>understand</b> how to calculate and model forces of dynamic systems</li> <li>• Must be able to select and <b>apply</b> methods for modelling the analogy between various dynamic systems i.e. electronic, mechanical and hydraulic systems</li> </ul> <p><b>Competencies</b></p> <ul style="list-style-type: none"> <li>• Must be able to <b>understand</b> how to collaborate within teams designing, building and modelling physical artefacts</li> <li>• Must be able to <b>synthesize</b> methods for modelling of physical systems and analogies between various dynamic systems such as electronic and hydraulic systems</li> </ul>
<p><b>Type of instruction:</b> Refer to the overview of instruction types listed in the start of chapter 3. The types of instruction for this course are decided in accordance with the current Framework Provisions and directions are decided and given by the Study Board for Media Technology.</p>
<p><b>Exam format:</b> In accordance with the current Framework Provisions and directions on examination from the Study Board for Media Technology:          Individual oral or written examination with internal censor. The assessment is performed with the Pass/Non-Pass grade.</p>
<p><b>Evaluation criteria:</b> The criteria for the evaluation are specified in the Framework Provisions.</p>

<p>Semester project:  <b>Sound and Music Innovation</b>  (Innovation i lyd og musik)</p> <p>Workload: 15 ECTS  Semester: 3rd semester</p>
<p><b>Prerequisites:</b>  2<sup>nd</sup> semester or equivalent</p>
<p><b>Objectives:</b>  Develop and evaluate a novel system that uses concepts and technologies in sound and music computing with a focus on exploring 1) its commercial aspects, and/or 2) its socio-cultural implications, and/or 3) its use in generating scientific knowledge.</p> <p>Students who complete the module will gain knowledge, skills and competences as follows:</p> <ul style="list-style-type: none"> <li><b>Knowledge:</b> <ul style="list-style-type: none"> <li>• Must be able to <b>understand</b> core state-of-the-art concepts, theories, techniques and methodologies relating to the sub-area of sound and music that has been applied in the project.</li> <li>• Must be able to <b>synthesize</b> relevant concepts in media commercialization and innovation</li> </ul> </li> <li><b>Skills:</b> <ul style="list-style-type: none"> <li>• Must be able to <b>apply</b> market and trend analysis methods to a media product or production involving sound and/or music processing</li> <li>• Must be able to <b>apply</b> sound and music related tools and technologies to create products that are viable from a commercial, socio-cultural, and/or scientific perspective</li> </ul> </li> <li><b>Competencies:</b> <ul style="list-style-type: none"> <li>• Must be able to <b>evaluate</b> and select relevant sound and music theories, methods, and tools, with the specific aim of working towards creating new products, commercially viable products, or new knowledge</li> </ul> </li> </ul>
<p><b>Type of instruction:</b> Academically supervised student-governed problem oriented project work.</p>
<p><b>Exam format:</b> In accordance with the current Framework Provisions and directions on examination from the Study Board for Media Technology:  Oral examination with internal censor based on a written project report and a media-technological product plus an A/V-production that illustrates and summarizes the project. The assessment is performed in accordance with the 7-point grading scale.</p>
<p><b>Evaluation criteria:</b> The criteria for the evaluation are specified in the Framework Provisions.</p>

<p><b>Title:</b>  <b>Prototyping and Fabrication Techniques</b>  (Prototyping og fremstillingsteknikker)</p>
<p><b>Size:</b> 5 ECTS</p>
<p><b>Prerequisites:</b> BSc in Medialogy or equivalent</p>
<p><b>Objectives:</b>  In order to be part of a leading design team, it is essential to be able to develop and communicate new interaction design concepts for the implementation and production of future electronic devices. The course rationale is that students need to have an understanding of physical interaction design processes, where ideas are formed, developed and tested in proof-of-concept models that can be demonstrated to others via video, poster presentations, and working prototypes. The focus is on understanding and applying design and development strategies needed to move from concept to working prototype, with the most recent tools and techniques for producing new forms, input/output from computers and embedded systems, and interactive systems and devices. The course incorporates advanced fabrication techniques; students should be able to build a prototype for any concept they can imagine. By incorporating computer-assisted industrial and electronic design techniques, knowledge about specific design tools and procedures is gained. In order to be able to apply this knowledge, a thorough understanding of the many underlying concepts is required.</p> <p>Students who complete the module must acquire the following knowledge, skills and competences:</p> <p><b>Knowledge:</b></p> <ul style="list-style-type: none"> <li>• The student must have <b>knowledge</b> about various approaches to Concept Design methodologies</li> <li>• The student must have <b>knowledge</b> about standard methods and techniques for prototyping of new devices and systems</li> <li>• The student must be able to <b>understand</b> the relationship between concept development and implementation/fabrication, specifically regarding research-based prototyping techniques</li> </ul> <p><b>Skills:</b></p> <ul style="list-style-type: none"> <li>• The student must be able to <b>apply</b> concept design methods and prototyping techniques to real world scenarios involving fabrication of objects or systems with intended functionalities (e.g. responsive environments, interactive games, robots, musical interfaces, public installations, etc.) Specific skills to be gained by the student may include many of the following: <ul style="list-style-type: none"> <li>• <b>Knowledge</b> of concept development techniques</li> <li>• <b>Knowledge</b> of modelling and design tools</li> <li>• <b>Knowledge</b> of rapid prototyping techniques</li> <li>• <b>Understanding</b> advanced microcontroller programming</li> <li>• <b>Understanding</b> sensors, actuators, and displays</li> <li>• <b>Understanding</b> wired and wireless communication protocols</li> <li>• <b>Understanding</b> 3D input devices and haptics</li> <li>• <b>Understanding</b> iterative development (redesign/polish of product)</li> <li>• <b>Understanding</b> circuit design (schematic to printed circuit board)</li> <li>• <b>Understanding</b> Field Programmable Gate Arrays</li> </ul> </li> </ul> <p><b>Competencies:</b></p> <ul style="list-style-type: none"> <li>• The student must be able to <b>analyze</b> a problem, design a solution and translate it into an</li> </ul>

rapid prototyping design

- The student must be able to **analyze** his/her solutions in order to compare and assess the potential of different concept design methods and prototyping techniques, iteratively making the proper design choices
- The student must be able to **synthesize** results and concepts in a professional way equivalent to practices in both academic and industrial contexts

**Type of instruction:**

The types of instruction for this course are decided in accordance with the current Framework Provisions and directions are decided and given by the Study Board for Media Technology.

**Exam format:** In accordance with the current Framework Provisions and directions on examination from the Study Board for Media Technology:

Oral or written examination with internal censor. The assessment is performed with the Pass/Non-Pass grade.

**Evaluation criteria:** Are stated in the Framework Provisions.

<p><b>Title:</b>  <b>Research in Sound and Music Computing</b>  (Studier i lyd og musik)</p>
<p><b>Size:</b> 5 ECTS</p>
<p><b>Prerequisites:</b>  2<sup>nd</sup> semester</p>
<p><b>Objectives:</b>  The goal of this course is to perform advanced work in one specific area of sound and music computing, building upon the foundations gained in the 7<sup>th</sup> and 8<sup>th</sup> semester. Students explore state of the art theories and techniques in a formalized manner by analyzing a selection of new research texts in a specific area of sound and music computing through, e.g., critical annotations, paper presentations, reproduction of experiments, etc.  Possible areas of research are music information retrieval, music perception and cognition, sonic interaction design, sound and music signal analysis and synthesis and new interfaces for musical expression.</p> <p>Students who complete the module will gain knowledge, skills and competences as follows:</p> <p><b>Knowledge:</b></p> <ul style="list-style-type: none"> <li>• Must be able to <b>understand</b> theories and principles related to a specific area of sound and music computing.</li> </ul> <p><b>Skills:</b></p> <ul style="list-style-type: none"> <li>• Must be able to <b>analyze</b> research papers related to a specific area of sound and music computing</li> <li>• Must be able to <b>apply</b> concepts, tools, theories and technologies of sound and music computing to address a specific research problem</li> </ul> <p><b>Competencies:</b></p> <ul style="list-style-type: none"> <li>• Must be able to <b>synthesize</b> a specific topic in sound and music computing</li> </ul>
<p><b>Type of instruction:</b> Refer to the overview of instruction types listed in the start of chapter 3. The types of instruction for this course are decided in accordance with the current Framework Provisions and directions are decided and given by the Study Board for Media Technology.</p>
<p><b>Exam format:</b> In accordance with the current Framework Provisions and directions on examination from the Study Board for Media Technology:  Oral or written examination with internal censor. The assessment is performed in accordance with the 7-point grading scale.</p>
<p><b>Evaluation criteria:</b> The criteria for the evaluation are specified in the Framework Provisions.</p>

<p><b>Title:</b>  <b>Multimodal Perception and Cognition</b>  (Multimodal perception og kognition)</p>
<p><b>Size:</b> 5 ECTS</p>
<p><b>Prerequisites:</b> BSc in Medialogy or equivalent</p>
<p><b>Objectives:</b>  In interactive-immersive systems that rely on digital technology, human interactivity and responsiveness are directly linked to the processes of human perception and cognition. This course introduces current research trends and emerging paradigms on the relation between digital technologies and multi-modal perception and cognition. Particular emphasis is put on multi-modal perception processes that are usually involved in interactive digital media (e.g., visual, auditory, haptic, proprioception) and higher cognitive processes related to interactivity (e.g. multimodal integration, enaction, intelligibility, cognitive closure, affective states and emotions, spatial cognition and navigation).  The course draws relevant knowledge from a variety of disciplines and fields such as cognitive neuroscience, ecological psychology, biology, cognitive ergonomics and cognitive technologies. Different bio-behavioral and biofeedback methods for interaction design and assessment are also introduced (e.g. EEG, EMG, ECG, galvanic skin response, ocular measures) and new trends in integration of interactive digital technologies with cognitive processes are addressed (e.g. multi-modal interfaces and set-ups, brain-computer-interfaces, enactive interfaces). Finally, the course provides the opportunity for targeting the knowledge provided towards the specialization profile chosen by the student (Computer graphics, Sound and music, Interaction, Games).</p> <p>A student who completes the course module will obtain the following qualifications:</p> <p><b>Knowledge:</b></p> <ul style="list-style-type: none"> <li>• <b>Understanding</b> of the main paradigms, concepts and disciplines that contribute to multimodal perception research and cognition studies and which have relevance for the interaction of human subjects with immersive-interactive systems</li> <li>• <b>Knowledge</b> about the potentialities and limits that the human “perceptual apparatus” and the cognitive system present for the technology designer</li> <li>• <b>Understanding</b> of the relations between multimodal perception, higher cognitive functions, affective states and action</li> </ul> <p><b>Skills:</b></p> <ul style="list-style-type: none"> <li>• Ability to <b>apply</b> knowledge on human multimodal perception and cognition in the design of interactive digital systems</li> <li>• Ability to <b>apply</b> knowledge to the design perception and cognition tests related to the cross-modal action of two or more senses</li> <li>• Be able to <b>apply</b> biofeedback and bio-behavioral measurements in experimental designs</li> </ul> <p><b>Competencies:</b></p> <ul style="list-style-type: none"> <li>• Ability to <b>synthesize</b> knowledge and theoretical frameworks from a variety of relevant sources and disciplines, which contribute to the study of technology-cognition interaction</li> <li>• Be able to <b>synthesize</b> such knowledge in the design of multimodal interactive systems</li> <li>• Ability to <b>analyze</b> and interpret experimental work and literature in the field</li> </ul>
<p><b>Type of instruction:</b>  Refer to the overview of instruction types listed in the start of chapter 3. The types of instruction for</p>

this course are decided in accordance with the current Framework Provisions and directions are decided and given by the Study Board for Media Technology.

**Exam format:**

In accordance with the current Framework Provisions and directions on examination from the Study Board for Media Technology:

Oral or written examination with internal censor. The assessment is performed in accordance with the 7-point grading scale.

**Evaluation criteria:** The criteria for the evaluation are specified in the Framework Provisions.

**Master's Thesis**

(Kandidatspeciale)

Workload: 30 ECTS

Semester: 4<sup>th</sup> semester

**Prerequisites:**

All previous semesters (projects and course-modules) must have been passed (1<sup>st</sup> to 3<sup>rd</sup> semester)

**Objectives:**

To document that the student, independently or in a small group, is capable of planning and completing a major research project in the chosen specialization. The final thesis must document the student's ability to apply scientific theories and methods, critically analyze existing work, and synthesize new knowledge.

Students who complete the module will gain knowledge, skills and competences as follows:

**Knowledge:**

- Must have knowledge and **understanding** in one or more subject areas that are representative of the state of the art in the research community of sound and music computing.
- Can understand and, on a scientific basis, **apply** an area of sound and music computing and identify scientific problems.

**Skills:**

- **Synthesize** scientific methods and tools and general skills related to sound and music computing.
- Can **evaluate** and select among scientific theories, methods, tools and general skills and, on a scientific basis, advance new analyzes and solutions in sound and music computing.
- Can **synthesize** research-based knowledge and discuss professional and scientific problems with both peers and non-specialists.

**Competencies:**

- Can **synthesize** work and development situations that are complex, unpredictable and require new solutions.
- Can **apply** acquired knowledge to independently initiate and implement discipline-specific and interdisciplinary cooperation and assume professional responsibility
- Can independently **synthesize** and take responsibility for own professional development and specialisation

**Type of instruction:** Academically supervised student-governed problem oriented project work. The project is carried out individually or in small groups of a maximum of three students. At least one internal supervisor is assigned, who deals with the primary area of the project in his or her research.

**Exam format:** In accordance with the current Framework Provisions and directions on examination from the Study Board for Media Technology:

Oral examination with external censor based on a written project report and a media-technological product plus an A/V-production illustrating and summarizing the project. The assessment is performed in accordance with the 7-point grading scale.

**Evaluation criteria:** The criteria for the evaluation are specified in the Framework Provisions

## **Chapter 4: Entry into Force, Interim Provisions and Revision**

The curriculum is approved by the Dean of the Faculties of Engineering and Science and enters into force as of September 2014.

In accordance with the Framework Provisions and the Handbook on Quality Management for the Faculties of Engineering and Science 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).

The Master's thesis must include a Danish summary.<sup>3</sup> 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 program at a university in Denmark or abroad**

In the individual case, the Board of Studies can approve successfully completed (passed) program elements from other Master's programs in lieu of program elements in this program (credit transfer). The Board of Studies can also approve successfully completed (passed) program elements from another Danish program or a program outside of Denmark at the same level in lieu of program 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 Faculties of Engineering, Science and Medicine on their website.

In accordance with the current Framework Provisions and upon direction on examination from the Study Board for Media Technology, the following exam-format may be applied:

To be eligible to take the exam the student must have fulfilled:

- handing in of written assignments or the like
- completion of certain – or all – study activities

Note that if admittance to the exam or parts of the assessment is to be based on written work or

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<sup>3</sup> The Board of Studies can grant exemption from this.

exercises, a deadline is stipulated for when the work must be handed in. If the student hands in a paper/exercises after the deadline, the student has used an examination attempt.

#### **5.4 Exemption**

In exceptional circumstances, the Board of Studies 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.

#### **5.5 Additional information**

The current version of the curriculum is published on the Board of Studies' website, including more detailed information about the program, including exams.

#### **Completion of the Master's program**

The Master's program must be completed no later than four years after it was begun.

#### **Rules and requirements concerning the reading of texts in foreign languages and a statement of the foreign language knowledge**

It is assumed that the student can read academic texts in modern English and use reference works and similar.