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Chapter 9

The programme specific part of the curriculum for

MASTER OF SCIENCE (MSc) IN ENGINEERING (PHYSICS AND TECHNOLOGY)

CIVILINGENIØR, CAND. POLYT. I FYSIK OG TEKNOLOGI

Curriculum 2016, Version 2.0

Applicable to students admitted September 2016 onwards

Please note that this version is a translation from Danish. In the event of discrepancies or ambiguity between this translation and the Danish version, the Danish version shall prevail.

The curriculum is divided into general provisions (Chapters 1-8), a programme specific part (Chapter 9) and the module descriptions of the programme's individual course modules. Students should familiarise themselves with all three parts in order to get a complete overview of the provisions regulating the programme.

§1 Job Profiles

Physics and Technology is a multidisciplinary engineering master programme aimed at job functions that combine a fundamental understanding of physics with application oriented technological knowledge and reflection about how technology interact with the environment.

Graduates are primarily recruited for research and development in development-intensive manufacturing and consulting companies.

Graduate engineers in Physics and Technology are employed in the private as well as in the public sector. In general graduates are engaged in:

- Research and development
- Implementation of research methods and research results
- Entrepreneurship and innovation
- Consulting and project management

in the field of

- Optical spectroscopy
- Nanotechnology and materials technology including the use of state-of-the-art manufacturing and characterisation methods
- Manipulation of light on nanoscale (nanooptics)
- Design and realisation of optical systems
- Design and realisation of optical sensors
- Advanced signal analysis and processing.

§2 Competence Profile for the Programme

The master's programme in Physics and Technology is a research based programme which strengthens the competence profile of the bachelor programme in Physic and Technology or any corresponding qualifying bachelor degree. The programme is structured in accordance with the educational concept 'The Engineering Education Model of the University of Southern Denmark' or, in Danish, 'Den Syddanske Model for In-geniøruddannelser' (DSMI). The learning objectives and competence profile of the master programme are described in accordance with the learning objectives of the Danish Qualifications Framework in the categories competences, skills and knowledge. The below table shows in which courses the student achieves the qualifications mentioned – described as knowledge, skills and competences.

THE GRADUATE WITH A DEGREE IN PHYSICS AND TECHNOLOGY WILL HAVE ACQUIRED ...	TK-SENS (1. sem.)	TK-ESS (1.sem.)	TK-VIB (1. sem.)	TK-STOK (1. sem.)	TK-NUM (1. sem.)	TK-ADOP (2. sem)	TK-MS1 (2. sem.)	TK-NPHY (2. sem.)	MCMICRO2 (3. sem)	TK-SP (3/4. sem.)
KNOWLEDGE ABOUT										
Available classes of sensors and actuators, their properties, manufacturing, characterisation and the underlying theory of their function, strategies for measuring specific parameters as well as interfacing with sensors and actuators.	X	X	X	X		X		X	X	
Vibrations and waves in continuous, isolated or coupled systems, power transmission, vibration isolation, noise emission from plane surfaces as well as modal and statistical energy analysis of vibrations.			X				X			
Stochastic signals and noise, noise models, calculation and analysis of noise in systems as well as detection and filtering of stochastic noise.		X		X		X		X		
Iterative methods for interpolation, differentiation, integration, solving linear and non-linear systems of equations and solving higher order differential equations, including consistency and convergence of the methods.					X		X	X	X	
Frauenhofer and Fresnell diffraction, Fourier optics, the transformation of light polarisation in optical systems, spatial and temporal coherence, characteristics of the laser light and its transformation in optical systems, non-linear effects in optical materials, fiber optics and						X		X		

optical detectors.										
Quantum mechanical description of the free radiation area and the free molecule, atomic and molecule orbitals, approximations, and operators for solving electronic eigenvalue equation, time-dependent perturbation calculation, symmetry and group theory.							X			
Physical properties and applications of materials and systems with dimensions of nanometers, methods of characterisation for the study of nanometer-scale objects and the principles of nanoelectronic and nanophotonic components.								X	X	
Advanced micro-and nano-lithography techniques, backside processing, MEMS and NEMS, membranes and beams, micro-and nanofluidics, bonding and packing, as well as electronic measurement techniques for micro and nano components.									X	

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THE FOLLOWING SKILLS										
Ability to apply mathematical methods and tools, including numerical methods and simulation tools, as well as to analyse and develop new models for electrical and physical systems and their interaction.	X		X	X	X	X	X	X	X	X
Ability to design, implement, analyse and optimise a sensor platform with given specifications, including the ability to work systematically with advanced signal processing and analysis of stochastic signals.	X	X	X	X		X		X	X	X
Ability to describe, analyse and perform measurements on the vibrations of mechanical systems.			X							
Ability to discuss technical and scientific issues with peers as well as with non-specialists in English.	X	X	X	X	X	X	X	X	X	X

Ability to critically read and evaluate technical literature and research articles as well as to disseminate research based technical and scientific knowledge to different audiences.						X	X	X	X	X
Ability to set up, implement, evaluate and conclude on practical experiments related to special linear and non-linear optical effects.						X		X		
Ability to perform simple molecular spectroscopic measurements and analyse the spectra using quantum mechanical theory.							X			
Ability to design, produce and characterise micro- and nano components and systems using state-of-the-art process technology and characterisation techniques.									X	

THE GRADUATE WITH A DEGREE IN PHYSICS AND TECHNOLOGY WILL HAVE ACQUIRED ...	TK-SENS (1. sem.)	TK-ESS. (1.sem.)	TK-VIB (1. sem.)	TK-STOK (1. sem.)	TK-NUM (1. sem.)	TK-ADOP (2. sem)	TK-MS1 (2. sem.)	TK-NPHY (2. sem.)	MCMICRO2 3. sem)	TK-SP (3/4. sem.)
THE FOLLOWING COMPETENCES										
Ability to identify, formulate and solve technical development tasks which are complex, unpredictable and require new solutions, and which must be solved in a social and ethical context.								X	X	X
Ability to develop, execute, evaluate and conclude on experimental work in relation to the latest research based theory and empirical knowledge, including assessing uncertainties, sources of error and advisability of methods.		X	X			X		X	X	X
Ability to independently initiate, collaborate on and assume professional responsibility in academic and interdisciplinary projects within scientific development and research work where methods and tools from the programme's core courses are applied and where the work procedures require reflection, teamwork, independence and a high degree of innovation.								X	X	X

Ability to independently assume responsibility for structuring and enhancing own competences through independently planned learning, including the use of the latest research literature.						X	X	X	X	X

§3 Academic Progression of the Programme

The programme consists of the following subject coloumns:

- Sensor Technology
- Stochastic Processes
- Experimental Sensor Technology and Signal Processing
- Mechanical Vibrations
- Numerical Methods
- Advanced Optics
- Molecules and Radiation
- Nanophysics
- Micro- and Nanofabrication 2

§4 Structure of the Programme

Themes	
4th semester	Thesis*
3rd semester	Micro- and Nanofabrication 2, Thesis preparatory electives and opportunity for In-company Period
2nd semester	Advanced Optics, Moleculear Spectroscopy, Nanophysics, Numerical Methods and elective course
1st semester	Sensor Technology, Stochastic Processes and elective course

* If the master's thesis is experimental, the student may choose to spend the 10 ECTS electives on the 3rd semester on the thesis work. The master's thesis will then be extended to 40 ECTS.

§5 Programme Structure and Modules

<table>
<tr><th>Semester</th><th colspan="30">Modules</th></tr>
<tr><td>4th semester (spring)</td><td colspan="30">TK-SP30
Thesis</td></tr>
<tr><td>3rd semester (autumn)</td><td colspan="10">MCMICRO2: Micro- and Nanofabrication 2</td><td colspan="5">Elective</td><td colspan="5">Elective / In-company Period*</td><td colspan="5">Elective / In-company Period* / Thesis**</td><td colspan="5">Elective / In-company Period* / Thesis**</td></tr>
<tr><td>2nd semester (spring)</td><td colspan="10">TK-ADOP
Advanced Optics</td><td colspan="5">TK-MS1
Moleculear Spectroscopy</td><td colspan="5">TK-NUM
Numerical Methods</td><td colspan="5">TK-NPHY
Nanophysics</td><td colspan="5">Elective</td></tr>
<tr><td>1st semester (autumn)</td><td colspan="5">TK-STOK
Stochastic Processes</td><td colspan="5">TK-SENS
Sensor Technology</td><td colspan="5">TK-ESS
Experimental Sensor Technology and Signal Processing</td><td colspan="10">TK-VIB
Mechanical Vibrations</td><td colspan="5">Elective</td></tr>
<tr><td>ECTS</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td></tr>
</table>

* The student may choose to spend 15 ECTS elective courses on an In-company Period (TK-VF).

** If the master's thesis is experimental, the student may choose to spend 10 ECTS elective courses on the 3rd semester on the thesis work. The master's thesis will then be extended to 40 ECTS.

Students on a 4+4 PhD programme may use their 15 ECTS electives on third semester together with the 30 ECTS on fourth semester on a 45 ECTS master thesis.

§6 Description of the 1st Semester

SEMESTER THEME

Sensor Technology and Stochastic Processes

VALUE ARGUMENT

A common frame of reference for graduates in Physics and Technology is to, on a scientific basis, analyse and model physical sizes in relation to design and realisation of sensors, actuators and measuring systems.

LEARNING OBJECTIVES

Students can:

- explain and apply knowledge of stochastic processes as the basis of practical application and scientific analysis.
- analyse and explain measurement systems, including establishing a model for the transducer components, especially through the use of micro and nanotechnology
- characterise and design sensor components with specified properties, which are optimised by, e.g., the use of stochastic models.
- explain and describe vibrations of complex mechanical systems, as well as perform and document vibration measurements on selected structures
- apply numerical methods to solve mathematical problems drawn from practical engineering relevant examples, implement numerical calculations and evaluate sources of error in the calculations, and use CFD tools for simulation and analysis of flow and heat transfer.

MODULES

The semester includes the following constituent, compulsory modules:

- TK-STOK – Stochastic Processes (5 ECTS)
- TK-SENS – Sensor Technology (5 ECTS)
- TK-ESS – Experimental Sensor Technology and Signal Processing (5 ECTS)
- TK-VIB – Mechanical Vibrations (10 ECTS)

In addition the semester includes elective courses of 5 ECTS

STRUCTURE

The semester consists of a theoretical part with the courses TK-VIB Mechanical Vibrations, TK-STOK Stochastic Processes and TK-SENS Sensor Technology. These modules provide the theoretical and mathematical basis for TK-ESS Experimental Sensor Technology and Signal Processing as well as the practical part of TK-VIB Mechanical Vibrations.

The master programme is a direct continuation of the bachelor programme. First semester consists of courses that support the further course of study. These courses are structured in a way that makes them immediately accessible to the students based on knowledge of e.g. mathematics, physics, technology and signal processing acquired at the bachelor programme.

§7 Description of the 2nd Semester

SEMESTER THEME

Advanced Optics, Moleculear Spectroscopy, Nanophysics, Numerical Methods and elective course.

VALUE ARGUMENT

A common frame of reference for the master students in physics and technology is to, on a scientific basis, apply theory, methods and practice in advanced optics, molecular spectroscopy and nanotechnology.

LEARNING OBJECTIVES

Students can:

- explain and apply theory of the diffraction, polarisation and coherence of light and explain the technological applications of light characteristics and transformation of optical systems, non-linear effects in optical materials, fiber optics and optical detectors.
- set up, implement, evaluate and conclude on practical experiments in relation to linear and non-linear optical effects
- explain the quantum mechanical basis for molecular spectroscopy and apply the theory to quantitatively describe the electron and vibration spectra of simple molecules.
- explain how the physical properties of the materials and components change when the dimensions are reduced, as well as how these functionalities can be used in new materials and components (sensors, actuators, etc.).

MODULES

The semester includes the following constituent, compulsory modules:

- TK-ADOP – Advanced Optics (10 ECTS)
- TK-MS1 – Moleculear Spectroscopy (5 ECTS)
- TK-NPHY – Nanophysics (5 ECTS)
- TK-NUM – Numerical Methods (5 ECTS)

In addition the semester includes elective courses of 5 ECTS

STRUCTURE

The semester consists of TK-ADOP Advanced Optics, TK-MS1 Moleculear Spectroscopy, TK-NPHY Nanophysics and TK-NUM Numerical Methods, which together provide the basis for further specialisation on the two final semesters.

§8 Description of the 3rd Semester

SEMESTER THEME

Micro- and Nanofabrication 2, thesis preparatory electives and opportunity for in-company period.

VALUE ARGUMENT

Micro- and nanofabrication as well as individual study activities constitute a nessecary link and basis from the constituent courses to the final thesis work.

LEARNING OBJECTIVES

Students can:

- design, make and characterise micro-and nano components and systems using state-of-the-art process technology and characterisation techniques.

Added to that are learning objectives obtained in the elective courses, individual study activities, and thesis preparatory activities.

MODULES

The semester includes the following constituent, compulsory modules, 10 ECTS:

- MCMICRO2 – Micro- and Nanofabrication 2 (10 ECTS)

In addition, the semester includes elective courses of 20 ECTS.

Should the student choose to write a 40 ECTS thesis, the thesis work will start in the 3rd semester where it will replace elective courses of 10 ECTS.

STRUCTURE

The semester consists of MCMICRO2, Micro- and Nanofabrication 2 and elective activities which provide the individual basis for the final specialisation. The elective activities can be courses, individual activities, thesis preparatory activities and an in-company period.

STUDY ABROAD

It is possible to spend third semester at a university abroad, provided the courses are approved by the Academic Study Board of the Faculty of Engineering.

§9 Description of the 4th Semester

SEMESTER THEME

Master Thesis

During the 4th semester, the student will prepare a 30 ECTS thesis, or continue the work on a 40 ECTS thesis.

VALUE ARGUMENT

The thesis is a project that documents the student's engineering competences, skills and knowledge within a limited, relevant and engineering-specific subject.

The problem can be addressed from a theoretical, experimental or practical starting point.

LEARNING OBJECTIVES

Students can:

- explain relevant engineering knowledge based on the highest international research in the subject area
- explain and critically reflect on relevant knowledge in the subject area
- identify relevant scientific problems in the subject area
- evaluate, select from and apply scientific methods, tools and skills in the subject area
- develop new analysis models and approaches
- explain and discuss relevant professional and scientific problems
- manage work and development situations that are complex, unpredictable and require new approaches
- independently initiate and implement disciplinary and interdisciplinary collaboration and assume professional responsibility
- independently take responsibility for their own professional development and specialisation
- disseminate research-based technical knowledge
- express themselves in writing in a clear and understandable language.

MODULES

- TK-SP30 – Thesis (30 ECTS) or
- TK-SP40 – Thesis (40 ECTS)

The module is compulsory.

§10 Qualifying degrees

10.1. Qualifying degrees

Based on 10.2 – 10.4 the university has assessed that the below degrees qualify for admission to Master of Science in Engineering (Physics and Technology). The list is not exhaustive

- BSc in Engineering (Physics and Technology) – University of Southern Denmark (legal entitlement for admission)
- BSc in Physics – Faculty of Science, University of Southern Denmark
- BSc in Engineering (Physics and Nanotechnology) – DTU

Below degrees are qualifying depending on academic profile and specialisation

- BEng degrees in Electronic Engineering, Electrical Power Engineering and Mechatronics – University of Southern Denmark
- BSc in Engineering (Mechatronics) – University of Southern Denmark

Applicants who meet the requirements of 10.3 qualify for admission. Any additional courses necessary can be taken in accordance with 10.4. Students who are interested in a master degree in Physics and Technology are encouraged to contact the programme coordinator for advice regarding elective courses.

10.2 Level and content of qualifying degrees

Qualifying bachelor and professional bachelor degrees in the scientific and technical area where the level and content of the scientific and technical courses correspond to a bachelor of science degree or a bachelor of engineering degree in the subject area of the MSc in Engineering (Physics and Technology) programme.

10.3 Academic content of qualifying degree

MSc in Engineering (Physics and Technology) admits applicants with a bachelor degree or a professional bachelor degree in the subject area of the programme, primarily physics and electro technology cf. 10.2 provided that the degree covers:

Basic subjects in mathematics (mathematics, statistics and signal processing): minimum 30 ECTS
Basic subjects in physics and technology (mechanics, electronics, electrophysics, thermal physics, quantum mechanics, optic): minimum 45 ECTS.

10.4 Additional courses

Should the applicant's degree fail to meet the requirements mentioned in 10.1 - 10.3, it is possible to acquire the necessary skills through additional courses offered at the University of Southern Denmark. The extent of additional courses cannot exceed 15 ECTS.

Additional courses have to be taken after admission to the programme. The courses can be taken during the first two semesters of the programme and must be passed by the end of the first year of study. Additional courses are restricted to courses offered by the University of Southern Denmark as summer courses or parallel to the first year of the master programme.

10.5 Admission with a foreign degree

Applicants with a bachelor degree or professional bachelor degree from a foreign university who meet the requirements of 14.2 and 14.3 are eligible for admission subject to an academic assessment and comparison of whether the applicant's academic qualifications correspond to those of qualifying Danish degree.

10.6 Possible exemptions

Applicants whose bachelor degree or professional bachelor degree fails to meet the terms stated in 10.1 – 10.5 are not eligible for admission.

Applicants who do not hold a bachelor degree or a professional bachelor degree but who have the academic qualifications equivalent thereto are eligible for admission should their qualifications, based on an academic assessment and comparison, correspond to those of a qualifying Danish degree.

Two-year transitional arrangement regarding additional courses:
Completed and passed additional courses, i.e. single courses from existing bachelor programmes, may be included in the application for admission until 31 August 2016.

§11 External Examiners and Study Board

The study programme belongs under the Academic Study Board of the Faculty of Engineering and the Danish corps of external examiners for engineering programmes. Modules offered by the Faculty of Science belong under the corps of external examiners for science.

§12 Entry into Force and Amendments

1. Approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 14 September 2010.

2. Curriculum 2014 is approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 10 April 2014 (Version 1.0).

3. Curriculum 2015 is approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 27 January 2015 (Version 1.0).

4. Curriculum 2016 is approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 13 April 2016 (Version 1.0).

5. Amendments approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 25 May 2016 (Version 2.0).

6. Amendments approved by the Academic Study Board of the Faculty of Engineering and the Director of Studies on behalf of the Dean of the Faculty of Engineering on 18 April 2017 (Version 2.1).