The Faculty of Engineering and Science
The Study Board of Biotechnology, Chemistry and Environmental Engineering

AALBORG UNIVERSITY
DENMARK

Curriculum for the Master's Programme in Chemical Engineering

Aalborg University
September 2017

Campus Esbjerg

Preface:
Pursuant to Act 261 of March 18, 2015 on Universities (the University Act) with subsequent changes, the following curriculum for the Master's programme in chemical engineering is stipulated. The program also follows the Joint Programme Regulations and the Examination Policies and Procedures for The Technical Faculty of IT and Design, 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 program in Chemical Engineering is organised in accordance with the Ministry of Higher Education and Science's Order no. 1328 of November 15, 2016 on Bachelor's and Master's Programs at Universities (the Ministerial Order of the Study Programs) and Ministerial Order no. 1062 of June 30, 2016 on University Examinations (the Examination Order). Further reference is made to Ministerial Order no. 258 of March 18, 2015 (the Admission Order) and Ministerial Order no. 114 of February 3, 2015 (the Grading Scale Order) with subsequent changes.

1.2 Faculty affiliation
The Master's programme falls under the Faculty of Engineering and Science

1.3 Board of Studies affiliation
The Master's program falls under the Board of Studies for Biotechnology, Chemistry and Environmental Engineering

1.4. External Evaluation Corps
The programme falls under the external evaluator corps: ingeniøruddannelernes censorkorps - kemi

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

2.1 Admission
Applicants with a legal claim to admission (retskrav):
Applicants with one of the following degrees are entitled to admission:

- Bachelor in Chemical Engineering and Biotechnology, Aalborg University

Applicants without legal claim to admission:

- Bachelor i Kemiteknologi, Aalborg University

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 program entitles the graduate to the designation civilingeniør, cand.polyt. (candidatus/candidata polytechnices) i kemiteknik. The English designation is: Master of Science (MSc) in Engineering (chemical engineering).

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

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

> **A Candidatus graduate has the following competency profile:**
> A Candidatus graduate has competencies that have been acquired via a course of study that has taken place in a research environment.
> A Candidatus graduate is qualified for employment on the labour market on the basis of his or her academic discipline as well as for further research (PhD programmes). A

Candidatus graduate has, compared to a Bachelor, developed his or her academic knowledge and independence so as to be able to apply scientific theory and method on an independent basis within both an academic and a professional context.

2.5 Competence profile of the programme:

The graduate of the Master's programme:

Knowledge	• has knowledge that is based on the highest international research in one or more subject areas within chemical engineering e.g.: o Bio energy o Ceramics and photocatalysis o Chemicals in oil and gas industry o Environmental technology o Fossil fuels and enhanced oil recovery o Fungal Technology, o Natural products, o Polymer technology o Spectroscopy and data analysis • can understand and, on a scientific basis, reflect over the above mentioned knowledge and identify scientific problems
Skills	• masters the scientific methods, the tools and general skills related to employment within chemical engineering • can evaluate and select among scientific theories, methods, tools and general engineering 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 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 specialisation

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.

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

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).

Semester	Module	ECTS	Assessment	Exam
1st	Process Analysis	15	7-point scale	Internal
	Fluid Mechanics	5	7-point scale	Internal
	Colloid and Interface Science	5	7-point scale	Internal
	Chemometrics	5	Pass/Fail	Internal
2nd	Process Modelling	15	7-point scale	External
	Process Simulation and Instrumentation	5	Pass/Fail	Internal
	Water Treatment	5	7-point scale	Internal
	Polymers and Properties of Polymers	5	7-point scale	Internal
3rd 3rd	Electives • Specialisation in Chemical Engineering • Project Work in an External Organisation	 30 30	 7-point scale Pass/fail	 External Internal
4th 3rd-4th	• Master's Thesis in Chemical Engineering • Master's Thesis in Chemical Engineering	30 60	7-point scale 7-point scale	External External
Total		120		

3.1 Descriptions of modules. 1st semester. Process analysis

Title: **Process Analysis**
Procesanalyse

Objective: Students who complete the module must be able to:

Knowledge
- account for which theoretical, numerical and experimental tools are available to solve the selected problem in process analysis
- explain the physical, chemical and mathematical theory behind the selected tools

Skills
- apply instruments, equipment, data sampling systems, instrumental chemical analysis to solve the problem.
- evaluate which kind of theory and or equipment gives the fastest and most robust answer to the questions raised.
- write a project report following the standards of the field of study, include relevant original scientific literature, use the correct terminology, and communicate the research-based foundation, problem and results of the project in writing, graphically and orally in a coherent way
- assess and select relevant original scientific literature and current

scientific methods, models and other tools used in the project and asses the problem of the project and results in relevant scientific contexts and social conditions

Competencies

- transfer the obtained theory and methodology to other problems involving process analysis.
- handle the planning, implementation and management of complex and unpredictable research and/or developmental tasks and take professional responsibility for implementing academic assignments and interdisciplinary collaborations
- take responsibility for own professional development and specialization

Type of instruction: Project work

Exam format: Oral examination based on a written report.

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Fluid Mechanics**
Strømningslære

Objective: Students who complete the module must be able to:

Knowledge

- explain fundamental basis for the formulation and analysis of the statics and dynamics of the flow of viscous fluids
- account for fluid kinematics
- explain stresses in fluids, equation of motion, constitutive models and Navier-Stokes equations
- account for Reynolds averaging and turbulence models
- describe turbulent and laminar boundary layers including understanding of momentum equation for boundary layers
- explain the basic phenomena involved in multiphase flows

Skills

- plan, design and make experiments and to choose measurements methods suitable to the characteristics of the fluid
- determine and apply appropriate experimental methods to fluid flows
- apply appropriate analytical, semi-empirical and numerical methods for mathematical description of fluid dynamic problems
- use multiphase flow models

Competencies

- independently define and analyse scientific problems within the area of fluid dynamics
- independently be a part of professional and interdisciplinary development work within the area of fluid dynamics

Type of instruction: Lectures workshops, exercises, mini-projects, and self-studies

Exam format: Written or oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Colloid and Interface Science**
Kolloid- og grænsefladekemi

Objective: Students who complete the module must be able to:

Knowledge
- account for different types of colloids and their stability
- acount for adsorption at interfaces
- account for surfactants, wettability and emulsions
- account for different scattering techniques, X-ray methods and electron microscopy
- account for different disciplines in which the theory of colloid and interface science are beneficial for understanding details of products or processes
- explain the importance of size and interparticle forces that result in macroscopic properties of substances
- explain models of colloids and interfaces that can be used for the description and understanding of different colloid systems. This involves physical equations, diagrams, drawings and images.

Skills
- apply general theory of colloid science in combination with experimental tools
- evaluate which kinds of experimental tools that preferable can be used to enhance the physico-chemical understanding of a given process or product

Competencies
- Select and apply models to describe different colloidal systems and interfaces

Type of instruction Lectures laboratory problems and theoretical exercises

Exam format: Oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Chemometrics**
Kemometri

Objective: Students who complete the module must be able to:

Knowledge
- account for general methods for multivariate data analysis (principal component analysis, multiple linear regression, principal component regression, projection on latent structures, soft independent modelling of class analogy)
- account for methods for data preprocessing (centering, scaling, non-linear and spectroscopic preprocessing, orthogonal signal correction).
- explain basic methods for variable selection (Selectivity ratio, VIP, interval PLS, jack-knife)
- explain the theoretical background of these methods, their advantages

and limitations as well as possible applications
- explain how multivariate methods complement traditional statistical methods

Skills
- explore multivariate data, find groups and trends, detect and remove outliers
- calibrate and do proper validation of multivariate regression models, use these models for prediction
- evaluate if data need a preprocessing and which method to apply
- calibrate and evaluate models for data classification
- compare different regression and classification models and find which is the best
- use multivariate methods for analysis of real data from different applications.

Type of instruction: Lectures, classroom instruction, mini-projects

Exam format: Written examination

Evaluation criteria: As stated in the Joint Programme Regulations

3.2 Descriptions of modules. 2nd semester. Process modelling

Title: **Process Modelling**
Procesmodellering

Objective: Students who complete the module must be able to:

Knowledge
- describe one or more advanced programmes for numerical calculations of complex and/or big amounts of data
- explain the theory behind the programmes

Skills
- apply one of the programmes for numerical calculation of a selected process going on in the laboratory or at pilot scale
- evaluate the results of simulations and find and correct any wrong input data
- write a project report following the standards of the field of study, include relevant original scientific literature, use the correct terminology, and communicate the research-based foundation, problem and results of the project in writing, graphically and orally in a coherent way
- assess and select relevant original scientific literature and current scientific methods, models and other tools used in the project and asses the problem of the project and results in relevant scientific contexts and social conditions

Competencies
- present the setup of the model, the calculations and estimations of the results and to propose further work based on the results of calculation
- handle the planning, implementation and management of complex and

unpredictable research and/or developmental tasks and take professional responsibility for implementing academic assignments and interdisciplinary collaborations
- take responsibility for own professional development and specialization

Type of instruction: Project work

Exam format: Oral examination based on a written report.

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Process Simulation and Instrumentation**
Processimulering og instrumentering

Objective: Students who complete the module must be able to:

Knowledge
- account for the principles of process simulation
- explain process optimization using process simulation
- account for computational aspects of phase equilibria
- account for instrumentation and PFD & PID's
- describe commercial process simulators

Skills
- illustrate an actual process in a PFD
- convert a PFD into a working process simulation
- perform both steady-state and dynamic simulations

Competencies
- investigate a given case using simulation tools
- select an appropriate thermodynamic model for a given case

Type of instruction: Lectures, practical exercises, group and individual instructions

Exam format: Written or oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Water Treatment**
Teknisk vandbehandling

Objective: Students who complete the module must be able to:

Knowledge
- describe different water bodies in the society and its surroundings and their interaction with atmosphere
- describe natural and antropogenic pollutants, their origin and some ways to eliminate them
- explain which chemical compounds are normally present in groundwater,

surface water, sea water, brine and at which levels based on original water and weathering processes
- describe a normal Danish drinking water treatment system and a Danish waste water treatment system

Skills
- select a methodology from an array of advanced oxidative and reductive processes that separately or in common can solve a given recalcitrant water pollution problem
- select unit operations and purification methods for produced water and other industrial water types

Competencies
- use proper terminology in oral, written and graphical communication and documentation within water treatment technology

Type of instruction: Lectures supplemented with project work, workshops, presentation seminars, laboratory tests, and cases

Exam format: Oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Polymers and Properties of Polymers**
Polymere og polymeres egenskaber

Objective: Students who complete the module must be able to:

Knowledge
- explain polymerisation processes
- describe the influence of segments in polymers on the properties
- account for viscosity and solubility parameters for polymers
- account for degradation of polymers
- account for permeability and migration in polymers
- describe additives and their influence on the properties
- describe a polymer system

Skills
- analyze and describe analytical methods to receive the knowledge about the polymer system and of the properties for the system
- describe the properties of a polymer system

Competencies
- apply proper terminology in oral, written and graphical communication and documentation within polymers and properties of polymer systems

Type of instruction: Lectures and theoretical exercises

Exam format: Written or oral examination

Evaluation criteria: As stated in the Joint Programme Regulations

3.3 Descriptions of modules. 3rd-4th semester. Master's thesis

Title: **Specialisation in Chemical Engineering**
Specialisering i kemiteknologi

Objective: Students who complete the module must be able to:

Knowledge

- account for at least one of the following areas
    - bio energy
    - ceramics and photocatalysis
    - chemicals in oil and gas industry
    - environmental technology
    - fossil fuels and enhanced oil recovery,
    - fungal Technology
    - natural products,
    - polymer technology
    - spectroscopy and data analysis

Skills

- demonstrate skills in at least one of the following areas:
    - execution of laboratory experiments
    - application of physico-chemical models to chemical engineering products
    - processes or process units, application of process simulators to chemical engineering related processes (e.g. separation, kinetics)
- analysis of experimental data
- write a project report following the standards of the field of study, include relevant original scientific literature, use the correct terminology, and communicate the research-based foundation, problem and results of the project in writing, graphically and orally in a coherent way
- assess and select relevant original scientific literature and current scientific methods, models and other tools used in the project and asses the problem of the project and results in relevant scientific contexts and social conditions

Competencies

- identify key aspects of the problem/process under investigation
- select and combine experimental and theoretical methods, as appropriate, in order to solve complex problems in chemical engineering
- critical review of the methods used and the results obtained on the project work.
- handle the planning, implementation and management of complex and unpredictable research and/or developmental tasks and take professional responsibility for implementing academic assignments and interdisciplinary collaborations
- take responsibility for own professional development and specialization

Type of instruction Project work

Exam format: Oral examination based on a written report.

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Project Work in an External Organisation**
Projektarbejde i en ekstern organisation

Objective: Students who complete the module must be able to:

Knowledge
- explain the scientific basis of the work carried out by the external organisation

Skills
- master the scientific methods and general skills related to the project work in the external organisation
- write a report following the standards of the field of study, use the correct terminology and document extensive use of relevant and original scientific literature, and communicate and discuss the project's foundation, problem and results in writing, graphically and verbally in a coherent way
- critically assess and select relevant original scientific literature and current scientific methods, models and other tools used in the project and asses and discuss the problem of the project and results in relevant scientific contexts and social conditions
- evaluate the potential of the project for further development, assessing and incorporating relevant economic, ethical, environmental and other socially relevant factors

Competencies
- participate in development, innovation, and research and use scientific methods to solve complex tasks
- take professional responsibility to implement independent assignments and interdisciplinary collaborations
- independently take responsibility for own professional development and specialization

Type of instruction: Project work, supervised by an external supervisor in collaboration with an internal supervisor at Aalborg University
Project work in an external organisation must be in areas of relevance to the competence profile of the program

Exam format: Oral examination based on a written report.

Evaluation criteria: As stated in the Joint Programme Regulations

Title: **Master's Thesis in Chemical Engineering**
Kandidatspeciale i kemiteknik

Objective: Students who complete the module must be able to:

Knowledge
- explain the scientific basis and scientific issues in chemical engineering
- explain the highest international research within the thesis subject area

Skills
- master the scientific methods and general skills related to the thesis subject area
- write a project report following the standards of the field of study, use the correct terminology and document extensive use of relevant and original scientific literature, and communicate and discuss the project's research-based foundation, problem and results in writing, graphically and verbally in a coherent way
- critically assess and select relevant original scientific literature and current scientific methods, models and other tools used in the project and asses and discuss the problem of the project and results in relevant scientific contexts and social conditions
- evaluate the potential of the project for further development, assessing and incorporating relevant economic, ethical, environmental and other socially relevant factors

Competencies
- participate in and independently implement technological and scientific development and research, develop and implement experimental work and solve complex tasks using scientific methods
- handle the planning, implementation and management of complex and unpredictable research and/or developmental tasks and take professional responsibility to implement independent academic assignments and interdisciplinary collaborations
- independently take responsibility for own professional development and specialization

Type of instruction Project work.
A long Master's thesis of more than 30 ECTS must include work of experimental nature to an extend that corresponds to the ECTS load of the thesis.

Exam format: Oral examination based on a written report.

Evaluation criteria: As stated in the Joint Programme Regulations

Title:	**Problem Based Learning and Project Management** Problembaseret læring og projektledelse
Objective:	Students who complete the module must be able to: Day 1 • describe and discuss the Aalborg PBL model based on the three key words: group work, project work, problem orientation • identify an initial individual challenge when using a PBL approach Day 2 • develop and practice peer feedback skills • practice collaborative learning in a group • design a plan of action to deal with an initial individual PBL challenge or curiosity Day 3 • practice presentation skills • practice critical skills when giving feedback to peers • reflect on own and peer skills in relation to PBL practice
Type of instruction	Lectures and theoretical exercises
Exam format:	Internal assessment during the course/class participation according to the rules in the Examination Policies and Procedures of Faculty of Engineering and Science, Aalborg University. In this case the assessment is based on the oral performance during the course, which means that the student has to be active during the course time and participate in discussions. The course is an integrated part of the project for those not acquainted to the Aalborg PBL model, and is a precondition for participation in the project examination. In this way there will be no diploma for the course and it will not be visible on the academic transcripts
Evaluation criteria:	As stated in the Joint Programme Regulations

Chapter 4: Entry into Force, Interim Provisions and Revision

The curriculum is approved by the Dean of the Faculty of Engineering and Science and enters into force as of September 1, 2017.

Students who wish to complete their studies under the previous curriculum from 2011 must conclude their education by the summer examination period 2018 at the latest, since examinations under the previous curriculum are not offered after this time.

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 (or another foreign language upon approval by the Studyboard). If the project is written in English, the summary must be in Danish (the Studyboard can grant exemption from this). 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 Joint Programme Regulations 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.

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.

5.5 Rules and requirements for the reading of texts

At programmes taught in Danish, it is assumed that the student can read academic texts in modern Danish, Norwegian, Swedish and English and use reference works, etc., in other European languages. At programmes taught in English, it is assumed that the student can read academic texts and use reference work, etc., in English.

5.6 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.