SYDDANSK UNIVERSITET
UNIVERSITY OF SOUTHERN DENMARK

Chapter 9
The programme-specific part of the curriculum for the programme:

CIVILINGENIØR, CAND. POLYT. I KEMI
Master of Science in Chemical Engineering

Curriculum 2013, Version 1.0

Applicable to students admitted September 2013 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 a section with general provisions (Chapters 1-8), a programme-specific section (Chapter 9), and a section with descriptions of the programme's individual course modules. The student is advised to examine all three sections in order to get a complete overview of the provisions regulating the programme.

§1 Job profiles

Masters of Science in Chemical Engineering are trained to perform a variety of important vocational functions. The typical fields of work include

- Design, planning and commissioning of new process engineering plants, as well as development, optimisation and operation of existing plants, such as plants in chemical and biochemical production, environmental upgrading, food production, pharmaceutical production, etc.
- Research related to the development of products and processes where chemical or biotechnological aspects play a significant role, such as products and/or processes of chemical production, biorefining, energy conversion, food processing or handling of residual and waste products from industry and agriculture.
- Research related to the development and optimisation of processes of chemical synthesis and their associated catalysts.
- Research within the development of new materials with specific functional properties.
- Counselling and consultancy in private and public organisations working within the areas of chemistry, environment and biosystems.

§2 Competence profile for the programmes

Skill level objectives for the programmes are determined on the basis of the legislation and other regulation applicable to the area. Furthermore, emphasis is on the vocational functions that newly graduated engineers are expected to perform, and on the requirements regarding their continued personal and professional development after completion of the programmes.

A wide range of non-chemical engineering competences are required of newly graduated engineers, as described in the general section of the Curriculum.

Graduates in chemical engineering are expected:

A. to have acquired specific technical knowledge within the subject profiles of the programme, rooted in advanced research with an international perspective.

B. to be able to communicate and discuss knowledge and results of scientific work with recipients with a variety of vocational competences.

C. to be able to understand and describe scientific problems based on their own or others' research-based knowledge, and to formulate working hypotheses for scientific work.

D. to be able to use the methods and tools associated with the specific disciplines of the programme's subject profiles in relation to the job profile for the programme as described in §1.

E. to be able to initiate and contribute to technical and interdisciplinary collaboration, and to assume independent responsibility for their own assignments.

F. to be able to plan and pursue own professional and personal development.

Based on this knowledge, graduates in engineering must be able to solve complex technical problems and design and implement complex technological products and systems in a social context. To graduates in chemical engineering, this means that they are expected:

G. to be able to develop, design, plan, modify, and optimise chemical and biotechnical process engineering plants and products based on consideration of chemical engineering, biotechnical, resource and environmental aspects.

H. to be able to accomplish research and development assignments within the core technical competences of the programme: Biotechnology and biorefining, Functional materials, Chemical engineering or Eco-efficient Engineering

I. to be able to head the establishment and management of analytical laboratories and develop measuring methods for use in research and development

J. to be able to head the development and implementation of quality and risk management systems

K. to be able to accomplish counselling and consultancy assignments within the core technical competences of the programme: Biotechnology and biorefining, Functional materials, Chemical engineering or Eco-efficient Engineering.

The above final target competences are based partly on the general competences of engineering acquired under the DSMI educational concept, and partly on a technical foundation of competences within a range of technical, scientific and social disciplines described in the following under the technical pillars of the programme.

§3 Technical pillars of the programme

The technical competences of graduates in chemical engineering are attributable mainly to the following technical pillars, which apply to both the bachelor and master levels of the programme.

The bachelor level comprises the following eight technical pillars:

- Chemical Engineering
- General, inorganic and organic chemistry
- Biotechnology
- Physical chemistry and materials
- Environment and management
- Mathematic and physical models
- IT and experimental methodology
- Personal and learning competences

as described in Chapter 9 for the bachelor level of the chemical engineering programmes.

§4 Programme subject profiles

The master level of the programme consists of constituent courses and technical profile courses. In combination, the constituent courses provide the common technical foundation for graduates in chemical engineering.

At the master level, the following four subject profiles are offered:

- Biotechnology and biorefining
- Functional materials
- Chemical engineering
- Eco-efficient Engineering

§5 Programme structure and modules (by subject profile)

5.1 Subject profile: Biotechnology and biorefining

<table>
<tr><th>Semester</th><th colspan="30">STRUCTURE</th></tr>
<tr><td>4</td><td colspan="30">XC-SP30/XC-SP40
Thesis</td></tr>
<tr><td>3</td><td colspan="10">Elective courses/
XC-SP40 Thesis</td><td colspan="5">Elective course</td><td colspan="5">XC-VIM
Methods in Science</td><td colspan="10">XC-BIO3
Advanced Natural Product Chemistry</td></tr>
<tr><td>2</td><td colspan="5">Elective course</td><td colspan="5">XC-RIS1
Risk Management in Chem. and Biochem. Engineering</td><td colspan="10">XC-TM1
Technical Microbiology</td><td colspan="5">Elective course</td><td colspan="5">Elective course</td></tr>
<tr><td>1</td><td colspan="5">XC-NUM
Advanced Numerical Methods and Computational Fluid Dynamics</td><td colspan="5">KC-MDA
Multivariate Data Analysis and Chemometrics</td><td colspan="5">XC-FYK1
Advanced Physical Chemistry</td><td colspan="5">KC-KPBW
Biowaste Management</td><td colspan="5">XCM-BEM
Business Economics and Management</td><td colspan="5">01007601
BMB506 – Protein Chemistry</td></tr>
<tr><td>ECTS POINTS</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>

Explanation	ECTS, total
Constituent course	30
Profile courses	30
Elective courses	30

*For a 40 ECTS thesis

5.2 Subject profile: Functional materials

<table>
<tr><th>Semester</th><th colspan="30">STRUCTURE</th></tr>
<tr><td>4</td><td colspan="30">XC-SP30/XC-SP40
Thesis</td></tr>
<tr><td>3</td><td colspan="10">Elective courses/
XC-SP40 Thesis</td><td colspan="5">Elective course</td><td colspan="5">XC-VIM
Methods in Science</td><td colspan="5">XC-MSC4
Materials Characterisation</td><td colspan="5">XC-MSC5
Advanced Solid State Chemistry</td></tr>
<tr><td>2</td><td colspan="5">Elective course</td><td colspan="5">XC-RIS1
Risk Management in Chem. and Biochem. Engineering</td><td colspan="5">XC-MSC3
Chemical Metallurgy and Corrosion</td><td colspan="5">Elective course</td><td colspan="5">10002801
KE801 – Inorganic Chemistry B</td><td colspan="5">XC-MSC2
Preparative Solid State Chemistry</td></tr>
<tr><td>1</td><td colspan="5">XC-NUM
Advanced Numerical Methods and Computational Fluid Dynamics</td><td colspan="5">KC-MDA
Multivariate Data Analysis and Chemometrics</td><td colspan="5">XC-FYK1
Advanced Physical Chemistry</td><td colspan="5">XCM-BEM
Business Economics and Management</td><td colspan="5">Elective courses</td><td colspan="5">XC-MSC1
Basic Solid State Chemistry</td></tr>
<tr><td>ECTS POINTS</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>

Explanation	ECTS, total
Constituent courses	30
Profile courses	30
Elective courses	30

*For a 40 ECTS thesis

5.3 Subject profile: Chemical Engineering

<table>
<tr><td>Semester</td><td colspan="30">STRUCTURE</td></tr>
<tr><td>4</td><td colspan="30">XC-SP30/XC-SP40
Thesis</td></tr>
<tr><td>3</td><td colspan="10">Elective courses/
XC-SP40 Thesis</td><td colspan="5">Elective course</td><td colspan="5">XCM-BEM
Business Economics and Management</td><td colspan="5">XC-VIM
Methods in Science</td><td colspan="5">XC-REG2
Process Control of Chemical and Biochemical Processes</td></tr>
<tr><td>2</td><td colspan="5">Elective course</td><td colspan="5">XC-RIS1
Risk Management in Chem. and Biochem. Engineering</td><td colspan="5">XC-SEP2
Industrial Separation Technology</td><td colspan="5">XC-CRY1
Crystallisation and Processing of Pharmaceuticals</td><td colspan="5">Elective course</td><td colspan="5">XC-REA3
Modeling and Simulation of Non-ideal Reactors</td></tr>
<tr><td>1</td><td colspan="5">XC-NUM
Advanced Numerical Methods and Computational Fluid Dynamics</td><td colspan="5">KC-MDA
Multivariate Data Analysis and Chemometrics</td><td colspan="5">XC-FYK1
Advanced Physical Chemistry</td><td colspan="5">Elective course</td><td colspan="5">XC-MEM1
Industrial Membrane technology</td><td colspan="5">XC-CAT1
Heterogeneous Catalysis</td></tr>
<tr><td>ECTS POINTS</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>

Explanation	ECTS, total
Constituent courses	30
Profile courses	30
Elective courses	30

*For a 40 ECTS thesis

5.4 Subject Profile: Eco-efficient Engineering

<table>
<tr><th>Semester</th><th colspan="30">STRUKTUR</th></tr>
<tr><td>4.</td><td colspan="30">XC-SP30/XC-SP40
Speciale</td></tr>
<tr><td>3.</td><td colspan="10">Elective courses/
XC-SP40 Thesis</td><td colspan="5">Elective course</td><td colspan="5">Elective course</td><td colspan="5">XCM-BEM
Business Economics and Management</td><td colspan="5">XC-VIM
Methods in Science</td></tr>
<tr><td>2.</td><td colspan="5">Elective course</td><td colspan="10">X-IWT1
Industrial Water Technology</td><td colspan="10">XC-WAM
Waste Management – From Waste to Resources</td><td colspan="5">XC-RIS1
Risk Management in Chemical and Biochemical Engineering</td></tr>
<tr><td>1.</td><td colspan="5">XC-NUM
Advanced Numerical Methods and Computational Fluid Dynamics</td><td colspan="5">KC-MDA
Multivariate Data Analysis and Chemometrics</td><td colspan="5">XC-FYK1
Advanced Physical Chemistry</td><td colspan="10">XC-SYS1
System Analysis/Consequential Life Cycle Assessment</td><td colspan="5">Elective course</td></tr>
<tr><td>ECTS POINT</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>

Explanation	ECTS, total
Constituent courses	30
Profile courses	30
Elective courses	30

*For a 40 ECTS thesis

§6 Common constituent professional foundation

PURPOSE

The common constituent professional foundation serves a two-fold purpose: The first is to provide MSc. students with a set of advanced tools within numerical methods, chemometrics, and scientific working methods in general. These tools will enable them, on the basis of physical/chemical data, to solve complex technical problems within their chosen subject profile, and to implement the often complex technical solution to the problem. The second is to provide MSc. students with the required tools to implement solutions in a financially sound manner and with the least possible production and environmental risk for the surrounding society.

Subjects:

- Numerical methods
    - Numerical methods in linear algebra.
    - Iterative procedures for solving sets of algebraic equations.
    - Statistical methods for parameter estimation.
    - Data filtering and processing methods.
    - Numerical methods for solving ordinary and partial differential equation systems.
    - Fundamental structured programming exemplified by using MatLab.
- Chemometrics
    - Multivariate data analysis.
    - Multiple linear regression (MLR).
    - Principal component analysis (PCA).
    - Partial least squares regression (PLSR).
    - Data modelling and model validation.
    - Model optimisation and determination of significant parameters.
    - Experimental test designs.
- Physical chemistry
    - Statistical thermodynamics.
    - Thermodynamics of mixtures.
    - Thermodynamic properties of macromolecules.
- Scientific methodology
    - Working hypotheses for research assignments.
    - Scientific integrity and ethics.
    - Critical literature searches and source criticism.
    - Preparation of scientific reviews in article form.

  - Preparation of working documents: Method descriptions, testing and time schedules.
  - Use of GLP in connection with record-keeping and scientific documentation.
- Risk assessment
  - Applicable Danish and EU legislation and standards relating to chemical and biochemical production and food production
  - Methods for identifying hazards related to production facilities
  - Creation of event trees for identified accident scenarios
  - Development of fault/failure trees for production facilities and processes
  - Calculation of probabilities for identified accident scenarios
  - Emissions calculations
  - HAZOP analyses of production facilities and laboratories
  - Risk and safety management and its integration into the general enterprise management
- Finances
  - Business management and finances
  - Creation of a business plan
  - Methods for comparing and assessing investment proposals
  - Methods for comparing and assessing funding options
  - Activity, capacity and cash flow budgeting
  - Analysis of profitability, earnings capacity, capital adjustment and solvency based on annual reports

§7 Subject profile: Biotechnology and biorefining

PURPOSE

In combination with the competences acquired at the bachelor level, the subject profile in biotechnology and biorefining aims to ensure that the Master of Science in Chemical Engineering develops his/her knowledge and competences based on the profession's scientific foundation and practice. The student acquires a high level of research knowledge and understanding as well as competences to describe and contribute technological and system engineering solutions within the biotechnical and environmental area. More specifically, the competences may be used in connection with biotechnological and microbial production, in the processing of vegetable raw materials to make foods and feedstuffs, in pharmaceutical production, in energy production and in the accomplishment of environmental assignments.

The subject profile in biotechnology and biorefining, together with the competences acquired at the bachelor level, ensures that based on the profession's scientific foundation and practice, the Master of Science in Chemical Engineering is able to:

- Develop methods and processes for biotechnological and microbial production, including production of foods, natural medicines and bioenergy.
- Develop processes and technologies for energy conversion to ensure optimum utilisation of various types of biomass.
- Participate actively in research to develop new products and technologies within biotechnological production, energy conversion and environmental upgrading.
- Develop and apply models for developing and managing process plants for biotechnological production, energy conversion and environmental upgrading.
- Advise authorities and enterprises on the production of bioenergy and other technologies for environmental upgrading.

STRUCTURE OF THE SUBJECT PROFILE

In addition to the 30 ECTS worth of constituent courses, the subject profile Biotechnology and Biorefining consists of 30 ECTS in profile courses defining the subject profile, elective courses totalling 30 ECTS, and a 30 ECTS Master's Thesis.

If the student decides to complete a 40 ECTS Master's Thesis instead, work on the Thesis will start in the 3rd semester, replacing 10 ECTS worth of elective courses.

Subjects:

Protein chemistry

- Protein structures and protein folding models
- Post-translational protein modification
- Links between the structure and function of proteins
- Decomposition of proteins
- Protein chemical methods for purification and characterisation

Technical microbiology

- Mathematical models for microbial growth and product formation
- Batch, fed-batch, continuous, multi-stage, recirculating and immobilised systems
- Metabolism and product formation
- Purification of microbial products
- Regulatory mechanisms and genetic modification
- Reactor engineering: Design, agitation and aeration, sterilisation, measurement and regulation
- Fermentation on the laboratory scale: Establishment of fermentors with data collection and control, experimental measurements for characterisation of growth and product formation, calculations using computer-based models.

Advanced natural product chemistry

- Biosynthesis of secondary metabolites from plants, micro-organisms and aquatic organisms.
- Bioactivity of secondary metabolites
- Assay and bioassay-guided fractionation
- Isolation, characterisation and quantification of secondary metabolites by means of chromatographic and spectroscopic techniques.

Environmental technology for biowaste

- Fundamental system understanding of plant nutrient flows and conversion to energy
- Application and validation of models to support decisions
- Choice of energy conversion and environmental technology based on the description of the biomass and the requirements specification
- Identification of gas emissions and management of indoor climate (odour, ammonia and greenhouse gasses)
- Identification and management of emissions (plant nutrients, carbon and heavy metals)

PROGRESSION

The academic progression in the programme is ensured via the constituent courses and profile courses.

The biotechnical progression in the Biorefining subject profile consists mainly of the courses in Protein chemistry, Technical microbiology, Advanced natural product chemistry and Environmental engineering for biowaste. The course in Protein chemistry, together with the biotechnology competences acquired at the bachelor level, provides the basis for the courses in Technical microbiology and Advanced natural product chemistry. The course in Advanced natural product chemistry is also supported by the bachelor level courses in general and organic chemistry. The course in Environmental technology for biowaste is also supported by the competences in separation processes and biotechnology acquired at the bachelor level.

The constituent courses in Numerical methods and Multivariate data analysis provide the basis for modelling, analysis and calculation assignments in the courses in Technical microbiology and Environmental technology for biowaste and in the Master's Thesis.

Together with the courses in Scientific working methods and Finances, the biotechnical progression forms the basis for the final Master's Thesis.

If completion of the Thesis includes practical laboratory work, it will often be appropriate for the student to use the opportunity to write a 40 ECTS points Thesis.

§8 Subject profile: Functional materials

PURPOSE

The subject profile aims to ensure that graduates in engineering who have completed a programme in materials chemistry at SDU are able to develop and deliver solutions to complex problems of material technology within the chemical, petrochemical, energy technology and materials technology industries, as well as to implement these solutions. The subject profile aims to provide a high level of international research-based technical knowledge within the area of classic solid state chemistry and metallurgy, technical electrochemistry and energy conversion, while ensuring that the candidate will be able to use and further develop the scientific methodology within these areas.

In combination with the competences acquired at the bachelor level, the subject profile ensures that with a basis in the profession's scientific foundation and practice, the Master of Science in Chemical Engineering is able to:

- Design, synthesise and characterise materials with specific catalytic, electrocatalytic, ion-conducting, dielectric, magnetic or optical properties.
- Make optimum selections of materials, based on chemical, financial and technological criteria.
- Develop components or devices such as sensors or catalytic reactors (including fuel cells and batteries) that use these materials.
- Design and implement relevant characterisation and testing methods for these components and devices.
- Contribute to develop models for and make model calculations of these devices and, if required, provide the necessary input parameters.
- Contribute to integrating the devices in large technical or chemical engineering plants, and manage operation of these.

STRUCTURE OF THE SUBJECT PROFILE

In addition to the 30 ECTS worth of constituent courses, the subject profile Functional materials consists of 30 ECTS in profile courses defining the subject profile, elective courses totalling 30 ECTS and a 30 ECTS Master's Thesis. If the student decides to complete a 40 ECTS Master's Thesis instead, work on the Thesis will start in the 3rd semester, replacing 10 ECTS worth of elective courses.

Subjects:

- Material chemistry:
    - Financially significant minerals and raw materials
    - Selected technologically important structural types with electric, dielectric, magnetic or optical properties
    - Selected synthesis methods for the above compounds
    - Phase equilibrium
    - Defects chemistry and transport properties
    - Heterogeneous catalysis

- Chemical metallurgy
  - Financially significant minerals and ores
  - Chemical aspects of extractive recovery of Cu, Ni, Zn, Pb, Sn and Fe
  - Chemical and electrochemical principles behind the production of passive light metals: Mg, Al, Ti, Zr, Hf, Ag, Au
  - Corrosion and rate of corrosion
- Characterisation of solids
  - X-ray diffraction
  - Electron microscopy
  - Surface physical methods
  - Electrochemical methods
  - Thermal characterisation
  - Particle size distribution

PROGRESSION

The academic progression in the programme is ensured via the constituent courses and profile courses.

Together with the profile courses in Inorganic chemistry and Materials chemistry, the constituent course in Physical chemistry provides a solid chemical engineering foundation for the more application-oriented subjects in Synthetic solid state chemistry and Materials characterisation. Together with the introductory courses in chemistry, the bachelor level courses in materials science provide the required qualifications for understanding the specialised chemistry subjects of the subject profile. The common constituent courses' content of mathematics, statistics, risk assessment and finance, combined with the bachelor level's chemical engineering courses, provide the students with the required qualifications to develop, model and implement products and processes involving solids with specific chemical and physical properties. Along with the subject profile's other theoretical and practical courses, the constituent course in Scientific working methods provides the basis for the final Master's Thesis.

If completion of the Thesis includes practical laboratory work, it will often be appropriate for the student to use the opportunity to write a 40 ECTS points Thesis.

§9 Subject profile: Chemical Engineering

PURPOSE

The subject profile aims to ensure that graduates in engineering who have completed a chemical engineering programme at SDU are able to develop and deliver technical solutions to complex production problems within the chemical, pharmaceutical, petrochemical and biochemical industries, as well as to implement these solutions. The subject profile aims to provide a high international level of research-based technical knowledge within the area of classic separation methods, membrane technology and reactor engineering, while ensuring that the candidate can use and further develop the scientific methodology within these areas.

In combination with the competences acquired at the bachelor level, the subject profile ensures that with a basis in the profession's scientific foundation and practice, the Master of Science in Chemical Engineering is able to:

- design new plants and sub-plants for use in the chemical, biochemical and pharmaceutical industries.
- develop new processing equipment for the chemical, biochemical and pharmaceutical industries.
- manage the operation of production facilities within the chemical, biochemical and pharmaceutical industries.
- participate actively in research and development within the chemical, biochemical and pharmaceutical industries.
- develop new models based on chemical, biochemical, physical and mathematical principles for the design of new processes and processing equipment.

STRUCTURE OF THE SUBJECT PROFILE

In addition to the 30 ECTS worth of constituent courses, the subject profile Chemical engineering consists of 35 ECTS in profile courses defining the subject profile, elective courses totalling 25 ECTS and a 30 ECTS Master's Thesis. If the student decides to complete a 40 ECTS Master's Thesis instead, work on the Thesis will start in the 3rd semester, replacing 10 ECTS worth of elective courses.

Subjects:

- Separation engineering
  - Selection and characterisation of membranes for separating fluids, gasses and microparticles
  - Description, modelling and simulation of mass and energy transport across membranes
  - Design, modelling and simulation of membrane modules
  - Design, modelling and simulation of entire membrane plants
  - Modelling, simulation and design of plants for non-stationary separation methods, e.g. chromatography, adsorption and ion exchange
  - Modelling, simulation and design of multi-component distillation plants
  - Optimisation and simulation of multi-column distillation plants

- Catalysis
  - Heterogeneous catalysis
  - Methods for examining the surface properties of solids
  - Methods for describing reaction mechanisms and reaction kinetics
  - Methods for estimating reaction rates
  - Experimental methods for determining reaction rates
  - The impact of internal and external mass and heat transport on reaction rates in heterogeneous catalysis.
- Crystallisation
  - Principles and mechanisms for crystallisation of pharmaceutical products
  - Thermal dynamics of solid state phases (amorphous, polymorphous, salts) for pharmaceutical products
  - Principles and mechanisms for phase transformation between solid state phases
  - Methods of analysis for identifying pure solids and mixtures of solids
- Reactor engineering:
  - Methods for developing models for quantitative description of conversion and heat generation in chemical and biochemical reactors
  - Modelling of fixed and fluid bed reactors
  - Modelling of multi-phase reactors
  - Modelling of membrane reactors
  - Designing and solving reactor models in MatLab.
  - Use of CFD tools in reactor simulations
- Regulating methods
  - Design of models to describe regulating loops for chemical engineering plants
  - Linearisation of non-linear systems of differential equations
  - Solving linear differential equations applying the Laplace transformation
  - Use of transfer functions and state models in regulating systems
  - Design of block diagrams of regulating loops
  - Optimisation and adjustment of forward and back connected regulation
  - Stability analysis for regulating loops
  - Simulation of regulating loops

PROGRESSION

The academic progression in the programme is ensured via the constituent courses and profile courses.

Together with the profile subject in Computational fluid dynamics, the constituent courses in Numerical methods and Statistics provide the mathematical basis for the profile courses in Reactor science, Separation processes and Regulating methods. Similarly, the courses in Physical chemistry and Heterogeneous catalysis combined with the competences acquired at the bachelor level provide the basis for the course in Reactor science. In addition to these technical elements, the course in Separation processes is supported by the course in Membrane technology and Crystallisation. Finally, the course in Regulating methods combines the competences from the courses in Numerical methods, Reactor science and Separation processes in a dynamic modelling component which permits regulation of the individual chemical engineering processing devices. This academic chemical engineering progression, combined with the constituent courses in Scientific working methods, Finances and Risk assessment, form the basis for the Master's Thesis.

If completion of the Thesis includes practical laboratory work, it will often be appropriate for the student to use the opportunity to write a 40 ECTS points Thesis.

§10 Subject Profile: Eco-efficient Engineering

PURPOSE

The subject profile in Eco-efficient Engineering aims to ensure that graduates with this profile can develop solutions to issues related to chemical engineering and environmental engineering within the chemical, pharmaceutical and biochemical industries, as well as contribute to the planning, problem solving and counselling in the public sector. Students acquire a high level of research knowledge and skills in water technology, systems analysis and waste management and the graduate can apply and develop scientific and systematic methods related to these areas.

Combined with the competences acquired as bachelor students the subject profile aims to ensure that graduates, based on the profession's scientific foundations and practice, can:

- Analyse and assess environmental problems and apply research based methods to develop solutions.
- Develop processes and technologies for chemical engineering and biotechnological production with focus on environmental and energy efficiency, incl. water treatment technologies.
- Apply systems analysis, including plan and carry out an LCA as well as perform a simple energy systems analysis
- Develop and apply decision models for waste management and recycling.

STRUCTURE OF THE SUBJECT PROFILE

In addition to the 30 ECTS worth of constituent courses, the subject profile Eco-efficient Engineering consists of 30 ECTS profile courses, which define the subject profile, 30 ECTS elective courses and a 30 ECTS Master's Thesis. If the student decides to complete a 40 ECTS Master's Thesis instead, work on the Thesis will start in the 3rd semester, replacing 10 ECTS worth of elective courses.

Subjects:

Systems analysis

- Life cycle analysis (LCA) of products and systems using advanced methods
- Energy systems analysis (ESA), methods and tools
- Setting objectives and scope and locate data for systems analysis

Water technology

- Physical methods (filtering, sedimentation, radiation, evaporation)
- Chemical methods (oxidation, separation, adsorption)
- Biological methods
- Management of end products from water treatment

Waste

- Systems and hierarchy for waste management
- Innovative methods for waste treatment
- Application of LCA for analysis of waste management and treatment

PROGRESSION

The academic progression in the programme is ensured via the constituent courses and the profile courses.

The constituent courses in numerical methods and multivariate data analysis enable graduates to solve mathematical problems and analyse complex data. The profile courses in systems analysis and waste management allow graduates to, based on the master and bachelor courses in chemistry and chemical engineering, solve problems in environmental technology and to carry out life cycle analyses on systems and products. The course in water technology contributes, together with the courses in process technology and separation processes, to the graduate's competences in process development. The academic progression in environmental technology and systems analysis, together with the constituent courses in scientific methods, risk analysis and economy, form the basis for the Master's Thesis.

If completion of the Thesis includes practical laboratory work, it will often be appropriate for the student to use the opportunity to write a 40 ECTS points Thesis.

§11 Programme language

The programme's common constituent courses and programme-specific subjects are offered in English. In classes where all students and the teacher master Danish, teaching may be provided in Danish, whereas the written material will be available in English. If warranted by special circumstances, certain elective courses may be offered exclusively in Danish.

§12 Qualifying study programmes

1. Bachelor programmes with immediate eligibility for admission (*Retskravsbachelor*)

Bachelors of Science in Chemical Engineering (the bachelor programme) from the Institute of Chemical Engineering, Biotechnology and Environmental Technology at SDU

Bachelors of Science in Chemical Engineering from the Institute of Chemical Engineering, Biotechnology and Environmental Technology at SDU are immediately eligible for admission to the Master's level of the Chemical Engineering programme. All subject profiles require successful completion of the module X-REA1 Design of Ideal Reactors from the bachelor programme. Admission to the Chemical engineering subject profile requires successful completion of the modules KE524 Quantum chemistry and KE525 Inorganic chemistry A at the bachelor level. Admission to the Biotechnology and biorefining subject profile requires successful completion of the module KE525 Inorganic chemistry A at the bachelor level. Admission to the subject profile in Eco-efficient Engineering requires successful completion of the module X-ENAP Environmental Assessment of Products.

2. Other qualifying Bachelor programmes from the University of Southern Denmark

Bachelors of Science in Chemical Engineering from the Institute of Chemical Engineering, Biotechnology and Environmental Technology at SDU

Bachelors of Science in Chemical Engineering from the Institute of Chemical Engineering, Biotechnology and Environmental Technology at SDU are immediately eligible for admission to the Master's level of the Chemical Engineering programme, provided the required qualifications have been attained via elective courses completed during the BSc (Eng.) programme or later. For all subject profiles, the course X-REA1 Design of Ideal Reactors must be passed. Admission to the Chemical engineering subject profile requires the modules KE524 Quantum chemistry and KE525 Inorganic chemistry A to be successfully completed in advance (or completed during the 1st semester of the master programme). Admission to the biotechnology and biorefining subject profile requires the module KE525 Inorganic chemistry A to be successfully completed in advance (or completed during the 1st semester of the master programme).

3. Other qualifying programmes, general

Bachelors and Bachelors of Science in Chemical Engineering from other universities

Bachelors and Bachelors of Science in Engineering from other (Danish and foreign) universities are immediately eligible for admission to the programme, provided their technical qualifications correspond to those of admission-eligible Bachelors or Bachelors of Science in Engineering from the Institute of Chemical Engineering, Biotechnology and Environmental Technology at SDU. Admission will be subject to individual assessment.

Other programmes

Bachelors of Science in Engineering from non-chemistry-related programmes may be admitted subject to individual assessment. Bachelors of Science in Chemical Engineering can be admitted to the subject profile Organic synthesis and catalysis if they have acquired the required qualifications to attend the profile courses via elective courses at the Bachelor level and complete X-REA1 Design of Ideal Reactors or a similar module. Bachelors of Science in Biochemistry or Microbiology may be admitted to the subject profile Biotechnology if they have acquired the required qualifications to attend the profile courses via elective courses at the bachelor level and complete the X-REA1 or similar module.

§13 Corps of Censors and Board of Studies

The programme belongs under the Board of Studies of the programmes at the Faculty of Engineering and the Danish national Corps of censors for the Engineering programmes. Modules offered by the Faculty of Science belong under the Corps of Science censors.

§14 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. Admission 2012 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 September 2012 (Version 1.0).
3. 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 31 December 2012 (Version 1.1).
4. 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 15 May 2013 (Version 1.2).
5. Curriculum 2013 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 19 June 2013 (Version 1.0).