UNIVERSITY OF SOUTHERN DENMARK

Chapter 9
The programme specific part of the curriculum for:

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

Study start: September 2010, Version 1.0

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 for the subjects studied for each programme. Students should familiarise themselves with all three parts in order to acquire a full overview of the rules that apply throughout the study programme.

1 Job profiles

Chemical engineers are qualified to pursue a career in a number of important fields. Typical work areas include:

- Designing, planning and commissioning of new process technology plants as well as developing, optimising and operating current plants. These could be plants within chemical and biochemical production, environmental improvements, food production, medicine production, etc.;
- Research in connection with the development of products and processes in which chemical or bio-technological conditions play an important role. These could be products and/or processes for chemical production, biorefining, energy conversion, food processing or handling of residual and waste products from industry and agriculture;
- Research in connection with the development and optimisation of chemical synthesis processes and associated catalysts;
- Research into the development of new materials with specific functional properties; and
- Advice and consultancy work in private and public enterprises within chemical engineering, the environment and biosystems.

2 The competency profile of the study programme

The competency goals of the study programme are laid down on the basis of legislation and ministerial orders in the area. The professions that the newly qualified engineers are expected to take on are also considered, as are the requirements for personal and professional development that fit in with the study programmes.
The newly qualified engineers are subject to a large number of competency requirements not specific to chemical engineers, as described in the general part of the study programme.
As far as graduate engineers are concerned, they must be able to solve complicated technical problems and design and implement complex technological products and systems in a social context. A special requirement for chemical engineers is that they will have achieved an advanced level of professional competence which enables them to:

- Design, plan, modify and optimise chemical and biotechnical processing plants and products on the basis of technical, resource and environmental considerations;
- Lead laboratory work and develop and validate analytical measuring methods;
- Handle consultancy assignments and administrative tasks within fields related to chemical engineering; and
- Be able to handle research and development tasks within the specialist areas of the study programme: Biorefining, Functional Materials, Chemical Technology or Organic Synthesis and Catalysis.

The final competencies listed above are based on the general engineering skills set out in the DSMI and on an academic grounding in competencies within a number of technical, scientific and social disciplines described below in the study programme's subject columns.

3 The subject columns of the study programme

3.1 The academic competencies for chemical engineers can primarily be attributed to the following subject columns which apply to the bachelor component and master component of the study programme respectively.
For the bachelor component the following eight subject columns apply:

- Chemical Engineering
- General, Inorganic and Organic Chemistry
- Biotechnology
- Physical Chemistry and Materials
- Environment and Management
- Mathematical and Physical Models
- IT and Experimental Methods
- Personal and Learning Competencies

As described in Chapter 9 for BSc (Eng) programmes in chemical engineering.

4 The academic profiles of the study programme

The master component of the study programme consists of constituent subjects and profile subjects. The constituent subjects together form the common professional ability of chemical engineers.

The master component offers the following four academic profiles:

- Biorefining
- Functional Materials
- Chemical Technology
- Organic Synthesis and Catalysis.

5 The structure and modules of the study programme (by profile)

5.1 Academic profile: Biorefining

<table>
<tr><td>Semester</td><td colspan="30">STRUCTURE</td></tr>
<tr><td>10</td><td colspan="30">Thesis</td></tr>
<tr><td>9</td><td colspan="10">Elective</td><td colspan="5">Elective</td><td colspan="5">XC-VIM1
Scientific Ethics and Methods</td><td colspan="10">XC-BIO3
Advanced Natural Product Chemistry</td></tr>
<tr><td>8</td><td colspan="5">XC-ECE1
Economics for Chemical Engineers</td><td colspan="5">XC-RIS1
Risk Analysis in Chem. and Biochem. Engineering</td><td colspan="10">KC-TCM
Technical Microbiology</td><td colspan="5">XC-KBW1
Biowaste Management</td><td colspan="5">Elective</td></tr>
<tr><td>7</td><td colspan="5">XC-NUM2
Advanced Numerical Methods for Chemi-cal Engineers</td><td colspan="5">KC-MDA
Multivariate Data Analysis and Chemometrics</td><td colspan="5">XC-FYK1
Advanced Physical Chemistry</td><td colspan="10">Elective</td><td colspan="5">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	Total ECTS points
Constituent subject	30
Profile subject	30
Elective	20

5.2 Academic Profile: Functional materials

Semester	STRUCTURE																												
10	**Thesis**																												
9	**Elective**										**Elective**										**XC-VIM1** Scientific Ethics and Methods					**XC-MK7**				
8	**XC-ECE1** Economics for Chemical Engineers					**XC-RIS1** Risk Analysis in Chem. and Biochem. Engineering					**XC-MK5** Chemical Metallurgy			**XC-MK4** Earth Materials		**XC-MK3** Materials Characterisation					**KE801** Inorganic Chemistry B					**XC-MK2** Preparative Solid State Chemistry				
7	**XC-NUM2** Advanced Numerical Methods for Chemical Engineers					**KC-MDA** Multivariate Data Analysis and Chemometrics					**XC-FYK1** Advanced Physical Chemistry					**Elective**										**XC-MK1** Basic Solid State Chemistry				
ECTS points	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

Explanation	Total ECTS points
Constituent subject	30
Profile subject	30
Elective	20

5.3 Academic Profile: Chemical Technology

Semester	STRUCTURE																													
10	**Thesis**																													
9	**Elective**										**Elective**										**XC-VIM1** **Scientific Ethics and Methods**					**XC-REG2** **Process Control of Chemical and Bio-chemical Processes**					
8	**XC-ECE1** **Economics for Chemical Engineers**					**XC-RIS1** **Risk Analysis in Chem. and Biochem. Engineering**					**XC-SEP2** **Industrial Separation Technology**					**XC-CAT2** **Homogeneous Ca-talysis**					**Elective**					**XC-REA3** **Modelling and Simu-lation of Non-ideal Reactors**				
7	**XC-NUM2** **Advanced Numerical Methods for Chemi-cal Engineers**					**KC-MDA** **Multivariate Data Analysis and Chemometrics**					**XC-FYK1** **Advanced Physical Chemistry**					**XC-MST1** **Modelling and Simu-lation of Transport Processes with Computational Fluid Dynamics**					**XC-MEM1** **Industrial Membrane Technology**					**XC-CAT1** **Heterogeneous Catalysis**				
ECTS points	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

Explanation	Total ECTS points
Constituent subject	30
Profile subject	35
Elective	15

5.4 Academic Profile: Organic Synthesis and Catalysis

Semester	STRUCTURE																																
10	**Thesis**																																
9	**Elective**										**Elective**					**XC-VIM1** Scientific Ethics and Methods					**XC-MDA1** Multivariate Data Analysis and Chemometrics					**KE-807** Physical Organic Chemistry						
8	**XC-ECE1** Economics for Chemical Engineers					**XC-RIS1** Risk Analysis in Chem. and Biochem. Engineering					**XC-CAT2** Homogeneous Catalysis					**Elective**					**Elective**											
7	**XC-NUM2** Advanced Numerical Methods for Chemical Engineers					**XC-FYK1** Advanced Physical Chemistry					**KE-818** Symmetry and Quantum Chemistry Supplement					**XC-CAT1** Heterogeneous Catalysis					**KE-804** Spectroscopy and Structural Chemistry									**KE-506** Synthesis				
ECTS points	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35

Explanation	Total ECTS points
Constituent subject	30
Profile subject	35
Elective	15

6 Common constituent professional skills base

Purpose
The purpose of the common constituent professional skills base is two-fold. The first part involves providing graduate engineering students with advanced tools within numerical methods, statistics and scientific working methods in general which enable them, based on physical chemistry data, to solve complicated technical problems within the selected subject column and implement the often complex technical solution to the problem. The second part involves providing graduate engineering students with the tools necessary to implement solutions with the lowest possible technical production and environmental risk to society at large in an economically justifiable way.

Subject columns:

- Numerical Methods
    - Numerical methods in linear algebra
    - Iterative procedures for solving sets of algebraic equations
    - Statistical methods for parameter estimation
    - Methods for data filtration and processing
    - Numerical methods for solving ordinary and partial differential equation systems
    - Basic structured programming exemplified by use of MatLab
- Statistics
    - 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 testing design
- Physical Chemistry
    - Statistical thermodynamics
    - Thermodynamics of mixtures
    - Thermodynamic properties of macromolecules
- Theory of Science
    - Working hypotheses for research tasks
    - Academic integrity and ethics
    - Critical literature searches and source criticism
    - Preparing scientific reviews in article form
    - Drawing up working documents: method descriptions, testing plans 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, biochemical and food production
    - Methods for identifying hazards in relation to production plants
    - Creation of event trees for identified accident scenarios
    - Creation of fault/failure trees for production plants and processes
    - Calculation of probabilities of identified accident scenarios
    - Emissions calculations
    - HAZOP analysis of production plants and laboratories
    - Risk and safety management and its integration into the enterprise’s general management

- Finance
    - Business management and finance
    - Creating a business plan
    - Methods for comparing and assessing investment proposals
    - Methods for comparing and assessing financing opportunities
    - Activity, capacity and cash flow budgeting
    - Analysis of profitability, earnings potential, capitalisation and solvency on the basis of annual reports.

7 Module descriptions

A detailed description of the common constituent subjects can be found in the module descriptions for the MSc (Eng) in Chemical Engineering. The module descriptions are found in the Course Database for the Faculty of Engineering on the Faculty's website.

8 Academic Profile: Biorefining

Purpose:
In combination with the competencies acquired from the bachelor programme, the academic profile in Biorefining shall ensure that engineers develop their knowledge and skills based on the profession's scientific foundation and practice. Students acquire a high level of research-related academic knowledge and understanding as well as the skills to describe and contribute technological and system engineering solutions within the biotechnical and environmental field. More specifically, these skills can be used in connection with biotechnological and microbial production, when refining vegetable raw materials into foods, fodder and natural medicines, when producing energy and to solve environmental tasks.

The academic profile in Biorefining and the skills acquired in the bachelor programme ensure that engineers can:

- Develop methods and processes for biotechnological and microbial production, including the production of food, natural medicines and bioenergy;
- Develop processes and technologies for energy conversion which ensure optimal utilisation of biomasses;
- Actively participate in research into the development of new products and technologies within biotechnological production, energy conversion and environmental improvement;
- Develop and use models for developing and managing process plants for biotechnological production, energy conversion and environmental improvement; and
- Advise authorities and companies on the production of bioenergy and other technologies for improving the environment.

The structure of the academic profile
In addition to the constituent subjects worth 30 ECTS points, the academic profile in Biorefining consists of profile subjects worth 30 ECTS points that define the academic profile, electives worth 30 ECTS points and a Master's Thesis worth 30 ECTS points.
If a student opts to write a thesis worth 40 ECTS points, the thesis is begun in the ninth semester and replaces an elective worth 10 ECTS points.

Subjects:
Protein Chemistry
- Protein structures and protein folding models
- Post-translation modifications of proteins
- Links between the structure and function of proteins
- Breakdown of proteins
- Protein chemical methods for purification and characterisation

Technical Microbiology
- Mathematical models for microbial growth and product formation
- Batch, fed-batch, continuous, multistage, recirculation and immobilised systems
- Metabolism and product formation
- Purification of microbial products
- Regulation mechanisms and genetic modification
- Reactor technology: composition, agitation and aeration, sterilisation, measurement and regulation
- Fermentation on laboratory scale: setting up fermenters with data collection and management, experimental measurements for characterisation of growth and product

formation, calculations when using computer-based models

Advanced Natural Product Chemistry

- Biosynthesis of secondary metabolites from plants, microorganisms and aquatic organisms
- Bioactivity of secondary metabolites
- Assay- and bioassay-guided fractionation
- Isolation, characterisation and quantification of secondary metabolites using chromatographic and spectroscopic techniques

Environmental Technology for Biowaste

- Basic system understanding of plant nutrition flows and conversion to energy
- Using and validating models for decision-making support
- Selection of energy conversion and environmental technology on the basis of the biomass description and requirements specification
- Identification of gas emissions and control of indoor climate (odour, ammonia and greenhouse gases)
- Identification and control of emissions (plant nutrition substances, carbon and heavy metals).

Progression

The academic progression in the study programme is guaranteed through the constituent subjects and profile subjects.

The biotechnical progression in the academic profile in Biorefining primarily consists of the courses in Protein Chemistry, Technical Microbiology, Advanced Natural Product Chemistry and Environmental Engineering for Biowaste. Together with the skills acquired from the bachelor component's biotechnological aspects, the course in Protein Chemistry constitutes 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 programme courses in General Chemistry and Organic Chemistry. The course in Environmental Engineering for Biowaste is furthermore supported by skills in separation processes and biotechnology from the bachelor programme.

The constituent subjects in Numerical Methods and Multivariate Data Analysis form the basis for modelling, analysis and calculation tasks in the Technical Microbiology and Environmental Technology for Biowaste courses and in the thesis.

Together with the courses in Scientific Working Methods and Finance, the biotechnical progression forms the basis for the final thesis.

If practical laboratory work is part of the thesis, it is often appropriate for the student in question to utilise the opportunity of writing a thesis worth 40 ECTS points.

9 Module descriptions

A detailed description of the constituent subjects for the academic profile in Biorefining can be found in the module descriptions for the MSc (Eng) in Chemical Engineering. The module descriptions are found in the Course Database for the Faculty of Engineering on the Faculty's website.

10 Academic Profile: Functional Materials

Purpose:
The academic profile shall ensure that graduate engineers trained in Material Chemistry at University of Southern Denmark are able to develop and deliver solutions to complicated material technological problems within the chemical, petrochemical, energy technology and material technology industries and to implement these solutions. More specifically, the study programme aims towards a high level of international academic, research-based knowledge of classic solid state chemistry and metallurgy, technical electrochemistry and energy conversion and for the master students to be able to use and further develop the scientific methods within these fields.
In combination with the competencies acquired from the bachelor programme, the academic profile ensures that, based on the profession's scientific foundations and practice, engineers can:

- Design, synthesise and characterise materials with specific catalytic, electrocatalytic, ion conduction, dielectric, magnetic or optical properties;
- Make optimal material selections based on chemical, financial and technological criteria;
- Develop components or devices such as sensors or catalytic reactors (including fuel cells and batteries) which use these materials;
- Set up and implement relevant characterisation and testing methods for these components and devices;
- Help to set up models for and carry out model calculations of these devices as well as producing the requisite input parameters if necessary; and
- Help to integrate the devices into larger technical or chemical engineering units as well as managing their operation.

The structure of the academic profile
In addition to the constituent subjects worth 30 ECTS points, the academic profile in Functional Materials consists of profile subjects worth 30 ECTS points that define the academic profile, electives worth 30 ECTS points and a Master's Thesis worth 30 ECTS points. If a student opts to write a thesis worth 40 ECTS points, the thesis is begun in the ninth semester and replaces an elective worth 10 ECTS points.

Subjects:

- Material Chemistry:
  - Financially valuable minerals and raw materials
  - Selected technologically important structure types with electric, dielectric, magnetic or optical properties
  - Selected synthesis methods for the abovementioned compounds
  - Phase equilibrium
  - Defect chemistry and transport properties
  - Heterogeneous catalysis

- Chemical Metallurgy
  - Financially valuable minerals and ores
  - Chemical aspects of extractive mining 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 solid substances
  - X-ray diffraction
  - Electron microscopy
  - Surface physical methods
  - Electrochemical methods
  - Thermal characterisation
  - Particle size distribution

Progression
The academic progression in the study programme is guaranteed through the constituent subjects and profile subjects.
Together with the profile subjects in Inorganic Chemical Engineering and Material Chemistry, the constituent subject in Physical Chemistry forms the basis for the more application-oriented courses in Synthetic Solid State Chemistry and Material Characterisation. Together with the introductory courses in Chemistry, the bachelor programme courses in Material Theory provide the necessary prerequisites for understanding the chemical fields of the subject profile. The common constituent subjects' content of mathematics, statistics, risk assessment and finance, together with the bachelor programme's chemical engineering courses, provides the necessary prerequisites for being able to develop, model and implement products and processes that involve solid substances with specific chemical and physical properties. The constituent subject in Science Theory forms the basis for the thesis together with the subject profile's other theoretical and practical courses.
If practical laboratory work is part of the thesis, it is often appropriate for the student in question to utilise the opportunity of writing a thesis worth 40 ECTS points.

11 Module descriptions

A detailed description of the constituent subjects for the academic profile in Functional Materials can be found in the module descriptions for the MSc (Eng) in Chemical Engineering. The module descriptions are found in the Course Database for the Faculty of Engineering on the Faculty's website.

12 Academic Profile: Chemical Technology

Purpose
The academic profile shall ensure that graduate engineers trained in Chemical Technology at University of Southern Denmark are able to develop and deliver technical solutions to complicated production problems within the chemical, pharmaceutical, petrochemical and biochemical industries and to implement these solutions. More specifically, the study programme aims towards a high level of international academic, research-based knowledge of classic separation techniques, membrane technology and reactor technology and for the students to master and be able to use and further develop the scientific methods within these fields.
In combination with the competencies acquired from the bachelor programme, the academic profile ensures that, based on the profession's scientific foundations and practice, engineers can:

- Design new plants and parts of new 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 plants within the chemical, biochemical and pharmaceutical industries;
- Actively participate in research and development within the chemical, biochemical and pharmaceutical industries; and
- Develop new models based on chemical, biochemical, physical and mathematical principles for the design of new processes and processing equipment.

The structure of the subject profile
In addition to the constituent subjects worth 30 ECTS points, the academic profile in Chemical Technology consists of profile subjects worth 35 ECTS points that define the academic profile, electives worth 25 ECTS points and a Master's Thesis worth 30 ECTS points. If a student opts to write a thesis worth 40 ECTS points, the thesis is begun in the ninth semester and replaces an elective worth 10 ECTS points.

Subjects:

- Separation Techniques
    - Selection and characterisation of membranes for separation of liquids, gases and microparticles
    - Description, modelling and simulation of mass and energy transfer across membranes
    - Design, modelling and simulation of membrane modules
    - Design, modelling and simulation of complete 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 multicomponent distillation plants
    - Optimisation and simulation of multicolumn distillation plants

- Catalysis
    - Homogeneous and heterogeneous catalysis
    - Methods for examining the surface properties of solid materials
    - Methods for describing reaction mechanisms and reaction kinetics
    - Methods for estimating reaction speeds

- Experimental methods for determining reaction speeds
- Effect of internal and external mass and heat transfer on the reaction speed in heterogeneous catalysis.

- Reactor Technology
  - 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 multiphase reactors
  - Modelling of membrane reactors
  - Set up and solution of reactor models in MatLab
  - Use of CFD tools in reactor simulation.

- Regulation Technology
  - Setting up models to describe regulation loops for chemical engineering plants
  - Linearisation of non-linear systems of differential equations
  - Solution of linear differential equations in Laplace transformation
  - Use of transfer functions and status models in regulation systems
  - Setting up block diagrams for regulation loops
  - Optimisation and adjustment of front- and back-connected regulation
  - Stability analysis for regulation loops
  - Simulation of regulation loops.

Progression
The academic progression in the study programme is guaranteed through the constituent subjects and profile subjects.
Together with the profile subject Computational Fluid Dynamics, the constituent subjects of Numerical Methods and Statistics form the mathematical basis for the profile subjects in Reactor Theory, Separation Processes and Regulation Technology. Together with the skills acquired in the bachelor component, the courses in Physical Chemistry and Heterogeneous Catalysis correspondingly form the basis for the course in Reactor Theory. In addition to these skills, the course in Separation Processes is supported by the course in Membrane Technology, while the course in Homogeneous Catalysis is primarily supported by the course in Heterogeneous Catalysis. Finally, the course in Regulation Technology gathers the skills from Numerical Methods, Reactor Theory and Separation Techniques into a single dynamic modelling component, which enables the regulation of the individual chemical engineering processing units. Together with the constituent subjects in Scientific Methods, Finance and Risk Assessment, this academic chemical engineering progression creates the basis for the thesis.
If practical laboratory work is part of the thesis, it is often appropriate for the student in question to utilise the opportunity of writing a thesis worth 40 ECTS points.

13 Module descriptions

A detailed description of the constituent subjects for the academic profile in Chemical Technology can be found in the module descriptions for the MSc (Eng) in Chemical Engineering. The module descriptions are found in the Course Database for the Faculty of Engineering on the Faculty's website.

14 Academic Profile: Organic Synthesis and Catalysis

Purpose
The academic profile shall ensure that graduate engineers trained in Organic Synthesis and Catalysis at University of Southern Denmark are able to develop solutions for product development and production within the organic chemical synthesis industry and the pharmaceutical industry and to implement these solutions. More specifically, the study programme aims towards a high level of international academic, research-based knowledge within stereospecific catalysis with organic synthesis and identification and for the students to master and be able to use and further develop the scientific methods within these fields.
In combination with the competencies acquired from the bachelor programme, the academic profile ensures that, based on the profession's scientific foundations and practice, engineers can:

- Develop new synthesis routes for the production of chemical compounds for use in the chemical, biochemical and pharmaceutical industries;
- Manage the operation of research and development laboratories within the organic chemical and pharmaceutical industries;
- Actively participate in research and development within the chemical, biochemical and pharmaceutical industries; and
- Develop new products based on chemical, biochemical and physical principles.

The structure of the academic profile
In addition to the constituent subjects worth 30 ECTS points, the academic profile in Organic Synthesis and Catalysis consists of profile subjects worth 35 ECTS points that define the subject profile, electives worth 25 ECTS points and a Master's Thesis worth 30 ECTS points. If a student opts to write a thesis worth 40 ECTS points, the thesis is begun in the ninth semester and replaces an elective worth 10 ECTS points.

Subjects:

- Theoretical Chemistry and Physical Organic Chemistry
    - The Schrödinger equation
    - Orbital theory
    - Interaction between light and matter
    - Electron spectra and photoelectron spectra
    - Stereochemistry, substitution and inversion reactions
    - Reactive intermediates
    - Linear free energy relationships and symmetry-controlled reactions
    - Organic chemical reaction mechanisms
    - Effect of chemical structures and reaction conditions on organic chemical reaction speeds
    - Determination of thermodynamic and empirical reaction parameters on the basis of experimental data
    - Methods for estimating organic chemical reaction speeds.

- Catalysis
    - Homogeneous and heterogeneous catalysis
    - Methods for examining the surface properties of solid materials
    - Methods for describing reaction mechanisms and reaction kinetics
    - Methods for estimating reaction speeds
    - Experimental methods for determining reaction speeds
    - Effect of internal and external mass and heat transfer on the reaction speed in heterogeneous catalysis.

- Organic Analytical Chemistry and Synthesis
    - Multistage syntheses
    - Unit operations in chemical synthesis
    - Organic chemical purification stage in the laboratory
    - Determination of synthesis product purity
    - Characterisation of organic compounds using spectroscopic methods
    - Carbon, nitrogen and phosphorus NMR spectroscopy
    - X-ray spectroscopy
    - Optical spectroscopy.

Progression
The academic progression in the study programme is guaranteed through the constituent subjects and profile subjects.
Together with the profile subject Quantum Chemistry and Symmetry, the constituent subjects within Numerical Methods and Statistics form the mathematical basis for the profile subjects in Catalysis and Physical Organic Chemistry. Together with the subjects in Catalysis and Physical Organic Chemistry, the courses in Organic Synthesis and Spectroscopy create the theoretical basis which enables the systematic development of new synthesis routes and production of new chemical products with specific properties. This academic physical chemical, spectroscopic and synthesis chemical progression within organic chemistry creates the basis for the thesis, together with the constituent subjects in Scientific Methods, Finance and Risk Assessment.
If practical laboratory work is part of the thesis, it is often appropriate for the student in question to utilise the opportunity of writing a thesis worth 40 ECTS points.

15 Module descriptions

A detailed description of the constituent subjects for the academic profile in Organic Synthesis and Catalysis can be found in the module descriptions for the MSc (Eng) in Chemical Engineering. The module descriptions are found in the Course Database for the Faculty of Engineering on the Faculty's website.

16 The language of the study programme

The common constituent subjects and profile subjects are offered in English. Should the teaching situation be such that all students and the lecturer speak Danish, then teaching can take place in Danish, but the teaching materials will be in English. Individual electives can, when justified by exceptional circumstances, be offered solely in Danish.

17 Admission to the study programme

Bachelors of Science in Chemical Engineering from the Institute of Chemical Engineering, Biotechnology and Environmental Technology at University of Southern Denmark
Bachelors of Science in Chemical Engineering from the Institute of Chemical Engineering, Biotechnology and Environmental Technology at University of Southern Denmark are automatically entitled to be admitted to the MSc (Eng) in Chemical Engineering. However, for admission to the Chemical Technology profile, course KE-512 must have been passed in the bachelor programme.

Bachelors of Engineering in Chemical Engineering from the Institute of Chemical Engineering, Biotechnology and Environmental Technology at University of Southern Denmark
Bachelors of Engineering in Chemical Engineering from the Institute of Chemical Engineering, Biotechnology and Environmental Technology at University of Southern Denmark are automatically entitled to be admitted to the MSc (Eng) in Chemical Engineering, provided that the conditions are met through electives taken during the Bachelor of Engineering study programme or later. For all subject profiles, course XB-REA1 must have been passed. Course KE-512 must have been passed for admission to the Chemical Technology profile, and course KE-512T must have been passed for admission to the Biorefining profile.

Bachelors of Science in Chemical Engineering, Biotechnology, etc. or Bachelors in Chemical Engineering from other universities
Bachelors of Science and Engineering from other universities may be automatically admitted to the study programme, provide their academic qualifications correspond to those of qualified Bachelors of Science in Engineering or Bachelor of Engineering educated at the Institute of Chemical Engineering, Biotechnology and Environmental Technology at University of Southern Denmark.

Other degrees
Bachelors of Engineering from study programmes that are not related to chemical engineering may be admitted following an individual evaluation. Bachelors of Science in Chemistry may be admitted to the Organic Synthesis and Catalysis profile, provided they have the qualifications necessary for the profile subjects via electives in the bachelor programme and complete course XB-REA1 or an equivalent course. Bachelors of Science in Biochemistry or Microbiology may be admitted to the Biotechnology profile, provided they have the qualifications necessary for the profile subjects via electives in the bachelor programme and complete course XB-REA1 or an equivalent course.

18 External examiners and Academic Study Board

The study programme falls under the Academic Study Board of the Faculty of Engineering and the Danish body of external examiners for engineering education.

19 Entry into force

Approved on 14 September 2010 by the Academic Study Board of the Faculty of Engineering.

Approved on 14 September 2010 by the Director of Studies on behalf of the Dean of the Faculty of Engineering.