How to read the course list

★ Exchange students may choose the course, but there are limitations on how many students can attend the course.

⊗ The course is not available for exchange students.

How to know whether you can attend a specific course

Please read the course description carefully and consider whether your skills and knowledge are sufficient

1. At the time of applying: your study plan/learning agreement will be checked after you have submitted all the application documents. Please do not contact the teaching personnel at this point.
2. After arrival: you will receive further instructions during the orientation and from the coordinators.
3. NOTE: Laboratory safety course CHEM-E0140 (0 cr) is compulsory for all students studying in the School of Chemical Engineering
4. 

Information about the courses

• As an exchange student, you should choose at least 2/3 of the courses from the field of study you are applying for. In addition, you can choose language courses and courses taught in the three other Schools of Technology: Engineering, Electrical Engineering, and Science.
• The extent of the courses is given in ECTS (= European Credit Transfer System) credits. One credit corresponds to 27 hours of work, including lectures and other forms of instruction, exercises, seminars and independent work at home and in the library.
• A full study load is approximately 1600 hours per academic year, which equals to 60 ECTS (=60 cr).
• CHEM-A and CHEM-C courses are bachelor's level, CHEM-E courses are master's level and CHEM-L courses are for doctoral students. P in the end of the course name indicates that the course is also suitable for doctoral students.
• Periods I and II refer to teaching periods of the autumn term, and periods III, IV and V refer to the teaching periods of the spring term.
• Remember also to read the course descriptions in MyCourses and WebOodi.
• Some changes in the courses for the next academic year are possible. Always check the latest information from WebOodi.
• Grading scale (please note that the conversion to ECTS grades is indicative, since Aalto University does not use the Gaussian Curve for grading):

<table>
<thead>
<tr>
<th>Aalto Grade</th>
<th>Indicative corresponding ECTS grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 (highest)</td>
<td>A</td>
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<tr>
<td>4</td>
<td>B</td>
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<td>3</td>
<td>C</td>
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<td>2</td>
<td>D</td>
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<tr>
<td>1 (lowest passing grade)</td>
<td>E</td>
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<tr>
<td>0 (failed, will not appear in the transcript of records)</td>
<td>F / FX</td>
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</table>
Bachelor’s level courses

CHEM-A1610 Design Meets Biomaterials (3-5 cr)

Responsible teacher: Tapani Vuorinen
Level of the Course: Bachelor level
Teaching Period: IV-V
Workload:
3 cr = 78 h
Lectures 20 h
Teamwork 58 h

Learning Outcomes:
- After the course the student will be able to recognize principles of experimental research and design methods
- Work out links between material performance and design
- Communicate and work in a multidisciplinary and international group

Content: Insight in biomaterials and their contemporary applications.
Assessment Methods and Criteria: Students will get an insight in biomaterials and their contemporary applications through lectures and multidisciplinary hands-on teamwork, using design methods. The teams will explore structural features and functional properties of selected biomaterials and design a product or a product concept that uses these biomaterials.
Study Material: To be announced during the course.
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-A1610
Grading Scale: 0-5
Registration for Courses: WebOodi
Language of instruction and studies: English
Further Information: Course is one of the Aalto courses. The amount of the students for this course is limited. Please see WebOodi for more information.

○ CHEM-C1200 Chemistry I (5 cr)

Responsible teacher: Miia Mäntymäki
Status of the Course: Aalto Bachelor’s Programme in Science and Technology, major course in Chemical Engineering
Level of the Course: Bachelor studies
Teaching Period: 2019-2020: I-II
Workload:
135 h 5 cr
The course consists of different sections:
- Laboratory safety course CHEM-E0140 in the beginning on the course
- Weekly lessons, which the students complete independently online
- Midterm exams or final exam

Learning Outcomes:
- After the course, student will be able to: 1. explain atomic structure and the basic principles of periodic table and describe different types of chemical bonds
2. explain the significance of bonding for structure and chemical and physical properties of matter, also from the point of view of applications
3. write chemical reaction equations as well as know the basics of chemical equilibrium, and is able to apply them in practice
4. describe interactions of electromagnetic radiation with matter, explain by means of them the structure of molecules as well as apply them in analyzing elements
5. work safely in a laboratory and document his/hers work

Content: General chemistry, where the following items are introduced: - atomic structure, periodic table, chemical bonding
- stoichiometry, reaction equations
- gases, liquid and solid state
- equilibrium reactions
- spectrophotometry, AAS, gravimetry, titrimetry

Assessment Methods and Criteria: Homework, laboratory work, and exam.
Substitutes for Courses: CHEM-A1200 Kemiallinen rakenne ja sitoutuminen
Prerequisites: Laboratory safety course CHEM-E0140 must have been passed before performing any laboratory work in this course.
Grading Scale: Fail, 1 - 5
Registration for Courses: WebOodi. This course is only for Chemical engineering majors and minors in Aalto Bachelor’s Programme in Science and Technology.
Language of instruction and studies: English

○ CHEM-C1210 Chemistry II (5 cr)

Responsible teacher: Miia Mäntymäki
Status of the Course: Aalto Bachelor’s Programme in Science and Technology, major course in Chemical Engineering
Level of the Course: Bachelor level
Teaching Period: 2019-2020: IV-V
Workload:
5 cr = 135 h
The course consists of different sections:
- Weekly lessons, which the students complete independently online
- Midterm exams or final exam

Learning Outcomes: After the course, student will be able to: 1. understand how the structure of a molecule is connected to its reactivity
2. write simple reaction mechanisms
3. understand the basics of reaction kinetics
4. design simple chemical reactions and carry them out
5. follow a chemical reaction with common analytical techniques

**Content:** Course deals with the basics of organic chemistry: molecular orbital theory, structure and reactivity, physical chemistry and reaction mechanisms.

**Assessment Methods and Criteria:** Homework, laboratory work, and exam


**Substitutes for Courses:** CHEM-A1210

**Prerequisites:** CHEM-C1200 Chemistry I.

Laboratory safety course CHEM-E0140 must have been passed before performing any laboratory work in this course.

**Grading Scale:** Fail, 1 - 5

**Registration for Courses:** WebOodi. This course is only for Chemical engineering majors and minors in Aalto Bachelor’s Programme in Science and Technology.

**Language of instruction and studies:** English

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**CHEM-C1300 Fundamental Biosciences (5 cr)**

**Responsible teacher:** Sandip Bankar

**Status of the Course:** Aalto Bachelor’s Programme in Science and Technology, major course in Chemical Engineering

**Level of the Course:** Bachelor level

**Teaching Period:** 2019-2020: III - IV

**Workload:** 5 cr = 135 h

**Contact hours (36h):**
- Lectures 12 x 2 (1 x weekly) = 24h
- Demonstrations in the laboratory or other assignments 4 x 3 = 12 h
- Student Independent work (99h)

**Electronic assignments, time approximated: 5 x 3h = 15h**

**Exam 4 h**

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**Independent study 80h**

**Learning Outcomes:** After completing the course the student will be able to:
- Name basic structures of cells (plant, microbe, animal)
- Present examples of the structure and function of amino acids and proteins in cells
- Describe at a general level the function of enzymes and the basics of enzyme kinetics
- Present selected cell energy metabolism and principal metabolic routes
- Produce examples of the structure and function of DNA and RNA in cells

**Content:** A basic course in biochemistry with focus on:
- Biomolecules (carbohydrates, amino acids, lipids, nucleic acids)
- How genes code for proteins
- Basics of biocatalysis and function of proteins: enzymes and their physical, chemical, biological and catalytic properties, enzyme kinetics, stability and activity
- Basics of cell energy metabolism

**Assessment Methods and Criteria:** The course includes lectures and group work. Students participate in laboratory demonstrations, calculation-assignments, and carry out given assignments independently or in a group. Grading is based on group and independent assignments completed during the course (e.g. demonstrations, study groups or other summaries or midterm tests) (25%) and course examination (75%). Failure to participate in lab demonstrations leads to a reduction in points (0.75 /missed demonstration).

**Study Material:** To be confirmed before start of the course.

**Substitutes for Courses:** CHEM-A1300 Biochemistry, CHEM-A1310 Basics of Bioscience and KE-30.2120 Biochemistry and Microbiology I

**Prerequisites:** Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018)

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**CHEM-C2150 Process Design (5 cr)**

**Responsible teacher:** Marjatta Louhi-Kultanen

**Level of the Course:** Bachelor level

**Teaching Period:** III – IV, first time in spring 2020

**Workload:** 5 cr = 135 h

Lectures 24-30 h, exercises 24-30 h, exam 5 h

Home assignments, self-studying, group work 70 h

**Learning Outcomes:** After the course student:
Understands the outline and context of process development
- Can preliminary design processes and size processing equipment
- Knows how to create preliminary investment and profitability calculations
- Is able to assess the effects of industrial processes and processing to health, safety and environment
- Knows the basic principles of process integration
- Can apply different purification methods for water, air and soil treatment
- Knows basic things in waste and chemicals legislation
- Can apply principal principles of Environmental impact assessment (EIA), Life cycle analysis (LCA) and circular economy
- Can apply the principles of sustainability and Health, safety and environment (HSE) for the assessment of chemical engineering processes

Content: - Process development path from idea to production
- Elementary issues of processes and processing equipment
- Principles of process R&D
- Basics of process design, documents and investment calculations
- Project lifecycle of industrial plant, engineering, procurement, construction management (EPCM)
- Maintenance and operation of plants
- Health, safety and environment, environmental impact assessment
- Waste water treatment, emission control and soil remediation,
- Circular economy (primary and secondary materials), waste to products and energy, industrial symbiosis
- Life cycle analysis
- Holistic evaluation of processes

Assessment Methods and Criteria: Lectures, exercises, group work, exam
Study Material: Lecturing materials, calculation exercises, group work outputs

Grading Scale: Fail, 1 – 5
Registration for Courses: WebOodi

Language of instruction and studies: English
CHEM-C2250 Chemistry III (5 cr)
Responsible teacher: Kari Laasonen
Status of the Course: Aalto Bachelor’s Programme in Science and Technology, major course in Chemical Engineering
Level of the Course: Bachelor level
Teaching Period: I-II, first time in Autumn 2020
Workload: 5 cr = 135 h
The course consists of different sections:
- Weekly lessons, which the students complete independently online
- Homework
- Weekly contact sessions where topics and homework for the week are discussed
- Laboratory work
- Midterm exams or final exam

Learning Outcomes: After the course the student will be able to - calculate the thermodynamic quantities of chemical reactions and to explain chemical and electrochemical equilibria using them - describe the working principle of an electrochemical cell and its use for energy production and electrochemical analysis - calculate the phase equilibria of pure substances and to interpret simple phase diagrams


Assessment Methods and Criteria: Homework, laboratory experiments and midterm exams/exam.

Study Material:
- Substitutes for Courses: CHEM-C2200 Kemiallinen termodynamikkka
- Prerequisites: CHEM-C1200 Chemistry I. Recommended: CHEM-C1210 Chemistry II.

Laboratory safety course CHEM-E0140 must have been passed before performing any laboratory work in this course.
Grading Scale: Fail, 1-5
Registration for Courses: WebOodi. This course is only for Chemical engineering majors in Aalto Bachelor’s Programme in Science and Technology or students who are studying in Chemical Engineering minor.

Language of instruction and studies: English
CHEM-C2330 Biochemistry (5 cr)
Responsible teacher: Silvan Scheller
Level of the Course: Bachelor and Master level
Teaching Period: I-II, first time in autumn 2020
Workload: Total 135h = 5cr
Lectures 24 h
Assignments or exercises 24 h
Other independent studying 84 h
Exam 3 h

Learning Outcomes: After the course, the student has the ability to:
- Give a detailed account of the main metabolic and catabolic pathways and homeostasis from a biochemical-enzymology point of view.
- Describe the function and components of major metabolic pathways and cell energetics to the larger biochemical system of the cell.

Content: This course presents a holistic approach to deep scientific and technical understanding of biochemistry. The core contents are energy metabolism, glycolysis, glycogen metabolism, signal transduction, transport through membranes, citric acid cycle, electron transport and oxidative phosphorylation, alternate pathways of carbohydrate metabolism, photosynthesis, synthesis and degradation of lipids metabolism, amino acid metabolism, energy metabolism, integration and organ specialization, and nucleotide metabolism.
Examples of enzyme function in carbohydrate hydrolysis and modification.
Assessment Methods and Criteria: The course consists of lectures, exercises and a written exam.

Study Material: To be announced

Substitutes for Courses: CHEM-E3100 Biochemistry

Prerequisites: CHEM-A1310 Biotieteinen perusteet, CHEM-C2310 Bioprosessitekniikka, or equivalent

Grading Scale: fail, 1-5

Registration for Courses: WebOodi

Language of instruction and studies: english

CHEM-C2340 Industrial Biomass Processes (5 cr)

Responsible teacher: Thaddeus Maloney

Level of the Course: Bachelor level

Teaching Period: III-IV, first time in spring 2020

Workload: 5 cr = 135 h
- Lectures 20-35 h
- Calculation exercises 5-20 h
- Home assignments, self-studying, group work 60-70 h
- Exam preparation 20 h

Learning Outcomes: After the course the student:
- recognizes different types of unit operations and industrial scale processes used in biomass valorization, conversion, bioprocessing and paper/board making
- knows the basic principles of these processes
- recognizes the main products manufactured with these processes and production plants
- understands the role of environmental technologies in industrial production processes
- understands how raw materials are used in a sustainable manner in production processes.

Content:
- Unit operations and processes
- Bioprocess technology processes
- Biorefineries and pulp production processes
- Paper and board manufacturing processes
- Production processes for mechanical wood products
- Industrial environmental technologies
- Sustainibility

Grading Scale: fail, 1-5

Registration for Courses: WebOodi

Language of instruction and studies: english

CHEM-C2460 Metallurgical Processes (5 cr)

Responsible teacher: Marko Kekkonen

Level of the Course: Bachelor level

Teaching Period: I-II, first time in autumn 2020

Workload: 5 cr = 135 h
- Lectures 24 h
- Calculation exercises 18 h
- Independent studies 66 h
- Studies for the exam 24 h
- Exam 3 h

Learning Outcomes: After completing the course the student:
- knows the unit operations and processes in materials production
- knows the most important phenomena affecting production processes of materials and the main natural laws affecting them
- is able to utilize basic technics in simulating typical processes in material processing at the equilibrium state
- knows the effect of phase equilibrium to processes and product properties

Content:
- Mechanical processes
- Pyro- and hydrometallurgical production processes
- Raw materials in different processes
- Processing and equipment of solid state materials
- Connection between the process conditions and product properties

Assessment Methods and Criteria: Home assignments and a written examination

Study Material:
- Lecture handouts
- Teräskirja, 2014 (Metallinjalostajat ry)

Substitutes for Courses:
- CHEM-C2110 Industrial Processes in Material Technology

Grading Scale: Fail, 1 - 5

Registration for Courses: WebOodi

Language of instruction and studies: English
can explain how the nanoscale features affect the mechanical, electrical, magnetic, optical, and thermal properties of materials
- understands the possibilities and limitations of different synthesis and coating technologies of nanostructures

Content: - Introduction to nanoscale science
- Stability of nanomaterials
- Properties at nanoscale: electrical, thermal, optical, magnetic, mechanical
- Nanoparticles and nanopowders
- Nanocarbon materials
- Thin films
- Optical nanostructures
- Soft nanomaterials
- Composites and hybrid materials

Assessment Methods and Criteria: Lectures, Exercises, group work project and exam.

Study Material: M. F. Ashby, P.J. Ferreira, D.L.Schodek, Nanomaterials, Nanotechnologies and Design – And Introduction for Engineers and Architects

Prerequisites: CHEM-A1410 Basics in Material Science
Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before academic year 2017-2018) Additional recommendations: CHEM-C2440 Microstructure of Metals and Ceramics and CHEM-C2450 Properties of Materials

Grading Scale: Fail, 1-5
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-C3410 Nanomaterials (5 cr)

Responsible teacher: Päivi Laaksonen
Level of the Course: Bachelor level
Teaching Period: I-II, first time in autumn 2020
Workload: cr = 135 h
- Lectures 24 h, 20 h independent work
- Exercises 10 h contact teaching, 20 h independent work
- Group work 6-12 h contact teaching, 18-24 h independent work
- Preparing for the exam 26 h
- Exam 4 h

Learning Outcomes: After the course, the student is able to describe the most important differences between nanomaterials and macroscopic materials

CHEM-C3420 Basics of Polymer Technology (5 cr)

Responsible teacher: Sami Lipponen
Status of the Course: Aalto Bachelor’s Programme in Science and Technology, major course in Chemical Engineering
Level of the Course: Bachelor level
Teaching Period: I-II, organized for the first time in 2021

Workload: 5 cr = 135 h. The course contains project work in groups, individual studying and evaluation. The course also includes contact teaching supporting the project work.

Learning Outcomes:
The course provides basic skills to specialize in material science including especially polymer technology.
After the course, the student has the ability to:
- identify the diversity and usability of polymers in different applications
- describe polymerization mechanisms and technical manufacturing methods
- understand how the size and form diversity of the molecules affect the properties of a material (e.g. thermal and mechanical properties)
- describe how a plastic product is manufactured from a polymer

Content: The learning outcomes of the course are principles of polymer science and technology as well as polymer structure property correlations. The course covers basics of polymer chemistry, polymer physics and polymer materials analysis and testing. The most important polymer types are introduced and their properties, uses, and manufacturing will be discussed. The students will get familiar with engineering polymers, specialty polymers and biopolymers. The course covers basics of polymerization and polymer processing technologies.

Assessment Methods and Criteria: The course consists of lectures and exercises to support the group projects. The course requires individual studying and participation in the final evaluation.

Study Material: Seppälä, J., Polymeeriteknologia perusteet, Otatieto no 580, Helsinki 2005, 346 s

Substitutes for Courses: CHEM-C2430 Polymeeriteknologia perusteet

Prerequisites: Basic knowledge in organic and inorganic chemistry

Grading Scale: Fail, 1-5
Registration for Courses: WebOodi
Language of instruction and studies: English
Courses of the Master’s programme of Chemical, Biochemical and Materials Engineering

CHEM-E0115 Planning and Execution of a Biorefinery Investment Project (5 cr)

Responsible teacher: Kyösti Ruutunen
Status of the Course: Master’s Programme in Chemical, Biochemical and Materials Engineering
Elective course in all majors
Level of the Course: Master’s level
Teaching Period: I-II
Workload:
5 cr = 5 x 27 h = 135 h
Lectures + examination: 50 h
Project work: 85 h

Learning Outcomes: After the course, the students are familiar with systematic planning, implementation and management of a biomass-based process industry investment project. The students will acquire experience in engineer’s work in a consultancy company, as well as working with tools for project planning. Moreover, the students have experience in project work in teams, as well as on report writing and giving oral presentations.

Content: The course provides an overview of an investment project and all the activities included during the entire lifecycle of a project (i.e. from early studies to startup of the plant). These activities include, for instance, process engineering, project implementation planning, implementation methods, contract-, scope-, resource-, time-, cost- and risk management and engineering tools. The course includes a practical process design oriented exercise using a real-life project case. A part of the lectures, as well as the practical exercise, is arranged in a consultancy company. The exercise includes an oral presentation on the results.

Assessment Methods and Criteria: Examination and project work. Further details given in My Courses workspace and in class.


Substitutes for Courses: Students who have passed course CHEM-E0110 Planning and Execution of Pulp and Paper Investment Project (3 cr) should be in contact with the teacher in charge before registering to this course.

Course Homepage: MyCourses
Prerequisites: Basic knowledge of process industry in the pulp and paper / forest biorefineries area;
B.Sc. degree.
Grading Scale: 0–5
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E0120 An Introduction to Wood Properties and Wood products (3-5 cr)

Responsible teacher: Mark Hughes
Level of the Course: Master’s level
Teaching Period: I-II
Workload:
3 cr = 81 h
- Lectures 0-30 h
- Other contact teaching 0-30 h
- Laboratory working 0-40 h
- Preparing for examination(s), simulations, exercises and reporting 0-50 h
- Examination(s) 2-10 h
Additional 2 cr = 54 h (optional)
- Individual project (topic and methods to be agreed with teacher in charge)

Learning Outcomes:
After the course student:
- Is familiar with tree growth and the ecological factors that affect it
- Knows the key anatomical features of wood and is able to differentiate important softwood and hardwood species from their microstructures
- Is familiar with the main chemical constituents of wood, their properties and how they make up the structure of the wood cell wall
- Knows about the anisotropic nature of wood and appreciates how the anatomical structure of wood affects its physical and mechanical properties
- Is familiar with the relationship between mass and volume in wood
- Knows the states of water in wood and is familiar with how water affects the mechanical and physical properties of wood, as well as how it affects its durability
- Is familiar with the thermal, electrical and acoustic properties of wood and appreciates its behaviour in fire
- Is familiar with the key physical and biological agents responsible for the degradation of wood and how degradation may be mitigated
- Knows about the short-term and long-term behaviour of wood under static and cyclic loading and appreciates how environmental factors affect this
- Appreciates how wood might be utilised in energy and resource efficient constructions
- Is able to describe the key steps in the manufacture of solid wood and wood-based composite products

Content: Wood is a plentiful and renewable resource that should play a strong role in sustainable construction. The aim of this course is to introduce students to the properties of wood and its material properties as well as some of the important wood-based products and how they are manufactured. There is emphasis on the properties and products of wood relevant to applications in the built environment. Topics include: Tree growth and ecology; wood species; wood anatomy; wood ultrastructure; moisture and wood; short-term and long-term mechanical properties; wood degradation; acoustic and thermal behaviour; wood products; wood product manufacturing.

Substitutes for Courses: Puu-28.5000 Introduction to wood properties and wood products
Grading Scale: 0-5
Language of instruction and studies: English
Further Information:
The target group of the course:
- Students of Wood Program (Architecture)
- Bachelor students of Aalto (especially CHEM, ARTS, ENG)
- Exchange students of materials science, polymer technology, civil and structural engineering, architecture, design or other

**CHEM-E0140 Laboratory Safety Course (0 cr)**

**Responsible teacher:** Kirsi Yliniemi  
**Status of the Course:** Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in CHEM school.  
**Level of the Course:** Bachelor and Master’s level  
**Teaching Period:** I, II, III, IV, V  
**Workload:** 6 h: Home exercises (in digital learning environment) or lectures  
3 h: Independent Study (studying the course material and making exercises)  
2 h: Exam  
**Learning Outcomes:** After this course student:
- Knows the basics laboratory safety practices in Aalto CHEM  
- Can identify possible risk factors in the laboratory environment  
- Is more aware of his/her own and fellow students’ safety  
**Content:** The course gives an overview of chemical safety (MSDS, warning symbols, etc.) and waste management in CHEM laboratories. Also, basic level of first-aid after typical laboratory accidents is discussed.  
**Assessment Methods and Criteria:** The course is undergoing digitalization which is planned to be ready by Autumn 2018. Before the digital course is ready:
- Period I: Compulsory attendance on lectures (3 x 2 h, held in September) and an oral group exam.  
- Period II-V: Home Exercises and an exam.  

**CHEM-E0150 Orientation for exchange students in the School of Chemical Engineering (1 cr)**

**Responsible teacher:** Tapani Vuorinen  
**Level of the Course:** Master’s level  
**Teaching Period:** I, III  
**Workload:** 27 h  
**Learning Outcomes:** After the course the student has:
1. Familiarized her/himself with the services offered by the School of Chemical Engineering and Aalto University  
2. Mastered the basic safety guidelines regarding working in a laboratory  
3. The knowledge to use IT-systems and online tools used when studying at Aalto University  
**Content:** The student participates in orientation sessions in the beginning of the term, completes Laboratory Safety and writes a short essay reflecting her/his arrival at Aalto University and answers the Orientation and Arrival feedback survey.  
**Assessment Methods and Criteria:** Participation in orientation sessions, laboratory safety, essay and independent work  
**Study Material:** To be announced later  
**Grading Scale:** Pass/fail  
**Registration for Courses:** WebOodi.  
**Language of instruction and studies:** English  
**Further Information:** Only for the exchange students in the School of Chemical Engineering

**CHEM-E1100 Plant Biomass (5 cr)**

**Responsible teacher:** Tapani Vuorinen  
**Level of the Course:** Master’s level  
**Teaching Period:** I (1st year)  
**Workload:** 135 h in total; lectures (20 h), laboratory work (80 h), excursion (5 h), self-studying (30 h)  
**Learning Outcomes:** Knowledge on existing and emerging sources of biomass for sustainable industrial use. Knowledge on practices (breeding, genetic modification, etc.) to affect growth of biomass and its properties. Ability to characterize chemical composition (gross chemical composition, chemical substance groups) and microscopic structure of biomass and understand these features on the level of plants’ physiological functions.  
**Content:** Industrially relevant plants and biomass fractions. Main physiological functions of plants and their anatomical and chemical features from macroscopic to microscopic and submicroscopic levels.  
**Study Material:** To be announced later  
**Course Homepage:** [https://mycourses.aalto.fi/course/search.php?search=CHEM-E1100](https://mycourses.aalto.fi/course/search.php?search=CHEM-E1100)  
**Grading Scale:** 0-5  
**Registration for Courses:** WebOodi  
**Language of instruction and studies:** English
**CHEM-E1110 Lignocellulose Chemistry (5 cr)**

**Responsible teacher:** Tapani Vuorinen  
**Level of the Course:** Master's level  
**Teaching Period:** II (1st year)  
**Workload:** 135 h in total; lectures (24 h), laboratory work (80 h), self-studying (31 h)  
**Learning Outcomes:** Laboratory skills to fractionate lignocellulose to its main constituents (cellulose, hemicelluloses, lignin, extractives) and characterize their chemical structure by chromatography and spectroscopy. Knowledge on characteristic reactions of the polysaccharides and lignin and ability to intercorrelate their structure and physicochemical properties.  
**Content:** Chemical structure, reactivity and physicochemical properties of cellulose, hemicelluloses, lignin and extractives. Preparative fractionation of lignocellulose to its constituents. Chemical characterization of the constituents by chromatographic and spectroscopic methods.  
**Study Material:** To be announced later  
**Course Homepage:** https://mycourses.aalto.fi/course/search.php?search=CHEM-E1110  
**Grading Scale:** 0-5  
**Registration for Courses:** WebOodi  
**Language of instruction and studies:** English

**CHEM-E1120 Thermochemical Processes (5 cr)**

**Responsible teacher:** Pekka Oinas  
**Level of the Course:** Master's level  
**Teaching Period:** III-V (1st year)  
**Workload:**  
- Lectures 20 h  
- Exercises 20 h  
- Project work 78 h  
- Other independent studying 17 h  
**Learning Outcomes:** After the course the student  
1. Model chemistry and thermodynamics related to thermochemical conversion and multiphase chemical equilibrium and mass transfer.  
2. Prepare market study of different biomass raw material, products, material margin and process alternatives.  
3. Utilize engineering tools to generate material and energy balances, sustainability analysis  
4. Create engineering design data for equipment sizing  
5. Estimate capital investment, operating and production costs  
6. Perform profitability analysis.  
7. Prepare a business model  
**Content:**  
- Design of thermochemical unit operations (Pyrolysis, Gasification, Combustion)  
- Process simulations to generate material and energy balances  
- Equipment sizing.  
- PFD and PI diagrams, lay-out and utilities, emissions and waste of the plant  
- Sustainability analysis  
- Design of process alternative concepts.  
- Capital investments, operating and production cost calculations  
- Profitability analysis  
- Business management and business model  
**Assessment Methods and Criteria:**  
- Lectures including visiting lecturers from industry  
- Project work in groups for plant design, feasibility study and business case - reporting seminar  
- Learning log  
**Study Material:** CHEM-E1120 Thermochemical processes; Project assignment (Oinas, Sarwar, Binari, Behm, Hohenthal, Oasmaa)  
**Course Homepage:** https://mycourses.aalto.fi/course/search.php?search=CHEM-E1120  
**Grading Scale:** 0-5  
**Registration for Courses:** WebOodi  
**Language of instruction and studies:** English

**CHEM-E1130 Catalysis (5 cr)**

**Responsible teacher:** Riikka Puurunen  
**Level of the Course:** Master's level  
**Teaching Period:** III-IV  
**Workload:** 135h in total  
- Lectures 28 h

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**CHEM-E1140 Catalysis for biomass refining (5 cr)**

**Responsible teacher:** Riikka Puurunen  
**Status of the Course:** Master's Programme in Chemical, Biochemical and Materials Engineering  
**Compulsory course in Biomass Refining major**  
**Level of the Course:** Master's level  
**Teaching Period:** IV-V

**Workload:** 5 cr = 135 h  
- lectures 22 h  
- Scientific review article 55 h
1. **Learning Outcomes**: After the course the student will be able to:
   - Understand the fundamental principles of heterogeneously catalyzed reactions.
   - Give a quantitative description of adsorption/desorption and the kinetics of catalytic reactions on a surface.
   - Account for how the catalytic activity and selectivity is influenced by the physical properties of a catalyst.
   - Understand the prerequisites of thermal stability of heterogeneous catalysts.
   - Understand the role of the different acidic sites of a solid acid catalyst and knows how to analyze those sites.
   - Describe the role of heterogeneous catalysis in novel biorefinery concepts in agreement with the rules of green chemistry.
   - Demonstrate knowledge of enzymatic and fermentation processes from the molecular and technical perspectives.
   - Understand the role of biological processes in catalyzing novel valorization processes of renewables.

1. **Assessment Methods and Criteria**: Part of the assessment is quizzes during the lectures.

1. **Course Homepage**: https://mycourses.aalto.fi/course/search.php?search =CHEM-E1140

1. **Grading Scale**: 0-5

1. **Language of instruction and studies**: English

### CHEM-E1150 Biomass Pretreatment and Fractionation - in Class (5 cr)

1. **Responsible teacher**: Herbert Sixta
2. **Status of the Course**: Master's Programme in Chemical, Biochemical and Materials Engineering Compulsory course in Biomass Refining major
3. **Level of the Course**: Master's level
4. **Teaching Period**: III-V (1st year)
5. **Workload**: 135 h in total; Lectures 30 h, Project work 45 h, Review articles on selected scientific topics from the literature 60 h

1. **Learning Outcomes**: After the course the student will be able to:
   - Understand the chemistry and technology of existing and novel fractionation processes and based in this knowledge can describe the principles of a forest biorefinery.
   - Be able to characterize the rheological properties of lignocellulosic polymers in solution (viscosimetry, light scattering, viscoelasticity) and the physicochemistry associated with chain molecules with special emphasis on natural polymers.
   - Understand the principles of the degradation and depolymerization reactions kinetics.
   - Make justified predictions about chemical reactions taking place during biomass refining processes in different conditions.
   - Explain the basics of the chemistry of novel solvents for lignocellulose and is able to describe the interactions of the solvents with biomass components using semi-empirical solvent parameters.

### Content: Special course covering chemical catalysis and biotechnology applications in biomass refining processes. The course deals with chemical and physical phenomena that are important within heterogeneous catalysis. The pore structure and surface properties of solid catalysts, their catalytic activity and selectivity, and stability towards hydrothermal treatment will be described in detail. Different cases where solid catalysts are used for the manufacture of high value-added products are presented and discussed. The use of enzymes as biocatalysts for the conversion of components isolated from biomass, preferably lignocellulose, into value-added intermediates and platform chemicals - optionally combined with subsequent fermentation - covers an essential part of the course. Further, instrumentation and methods for characterization of catalytic systems will be described. Important industrial processes for the exploitation of natural gas as well as the catalytic upgrading of pyrolysis oil will be described and used as examples. The course is well suited for master students with interests directly related to catalysis and PhD candidates working within related areas. The course includes lectures by visiting specialists from academia and industry; hence the state-of-the-art knowledge on the use of catalysts in different biorefinery cases is provided to the students.

### Assessment Methods and Criteria: Part of the assessment is quizzes during the lectures.

### Study Material: Lecture notes, text books:
1. **Principles and Practice of Heterogeneous Catalysis** (Thomson&Thomson), Beyond oil and gas: The Methanol Economy (G.A. Olah), Chemical Processes for a Sustainable Future (Trevor Letcher, Janet Scott and Darell Patterson), Green Chemistry and Catalysis (R.A. Sheldon, I. Arends, U. Hanefeld).

### Course Homepage: https://mycourses.aalto.fi/course/search.php?search =CHEM-E1140

### Grading Scale: 0-5

### Language of instruction and studies: English

### CHEM-E1150 Biomass Pretreatment and Fractionation - in Class (5 cr)

1. **Responsible teacher**: Herbert Sixta
2. **Status of the Course**: Master's Programme in Chemical, Biochemical and Materials Engineering Compulsory course in Biomass Refining major
3. **Level of the Course**: Master's level
4. **Teaching Period**: III-V (1st year)
5. **Workload**: 135 h in total; Lectures 30 h, Project work 45 h, Review articles on selected scientific topics from the literature 60 h
6. **Learning Outcomes**: After the course the student will be able to:
   - Understand the chemistry and technology of existing and novel fractionation processes and based in this knowledge can describe the principles of a forest biorefinery.
   - Be able to characterize the rheological properties of lignocellulosic polymers in solution (viscosimetry, light scattering, viscoelasticity) and the physicochemistry associated with chain molecules with special emphasis on natural polymers.
   - Understand the principles of the degradation and depolymerization reactions kinetics.
   - Make justified predictions about chemical reactions taking place during biomass refining processes in different conditions.
   - Explain the basics of the chemistry of novel solvents for lignocellulose and is able to describe the interactions of the solvents with biomass components using semi-empirical solvent parameters.
phase of the course, the students need to prepare a scientific review article on a selected topic in biorefineries.

**Study Material:** Lecture notes, text books on wood chemistry, pulping technology, biorefineries and green chemistry.

**Course Homepage:** https://mycourses.aalto.fi/course/search.php?search=CHEM-E1150

**Grading Scale:** 0-5

**Language of instruction and studies:** English

★ CHEM-E1160 Biomass Pretreatment and Fractionation - in Laboratory (5 cr)

**Responsible teacher:** Kyösti Ruuttunen

**Status of the Course:** Master’s Programme in Chemical, Biochemical and Materials Engineering

**Compulsory course in Biomass Refining major**

**Level of the Course:** Master’s level

**Teaching Period:** III-V (1st year)

**Workload:** 135 h in total; Lectures & workshops 20 h, Project work 115 h (including ca. 60 h practical laboratory work and ca. 55 h report writing and other tasks)

**Learning Outcomes:** After the course the student

1. understands the chemistry and technology of existing and novel fractionation processes and based on this knowledge can describe in detail the principles of a forest biorefinery
2. has practiced the most essential experimental and analytical methods in the area of biomass refining and is also familiar with some less conventional practical laboratory methods.
3. based on the practical experience, can make justified predictions about chemical reactions taking place during biomass refining processes in different conditions.
4. is able to describe the principles of the advanced analytical methods for structural characterization of lignocellulosic constituents.
5. is familiar with principles of project planning and has team-working experience; has practiced giving and receiving positive and constructive feedback.
6. is able to present a clear research project report both especially in written form but has also practiced giving oral presentations.

**Content:**

This is a parallel course with CHEM-E1150, Biomass Pretreatment and Fractionation – in Class. The idea behind this approach is that the students will be able to apply the theory learned during the lectures directly to practice in the laboratory. Based on the given options, student teams choose a biomass type and plan a fractionation scheme for it, aiming for producing a fibre product as well as products from the side streams (hemicellulose, lignin, or extractives). Subsequently, the team carries out the planned process in the laboratory. The laboratory work will include characterizing the biomass raw material with the appropriate methods (e.g. carbohydrate analysis, Klasson and acid soluble lignin), as well as testing the intermediate and final product properties (e.g. pulp kappa number, intrinsic viscosity, and brightness). The student teams compose a final report of their project, describing the procedure and also presenting a mass balance of the whole process and the individual steps. In addition, they have to describe how the process, which they designed and executed, would be carried out in industrial scale.

In addition to the practical laboratory work, instructing lectures and workshops are organized. Moreover, the teams will present their work orally and present observations about each other’s work during different stages of the project. The teams and its members will give and receive feedback of their performance both as a team and individually. The practical laboratory work is instructed mostly by Ph.D. students.

**Assessment Methods and Criteria:** Evaluation of the written project plan and reports. Peer and self-assessment will have an impact on the final course grade. The practical details of the assessment to be discussed with the students in class.

**Course Homepage:** To be announced in class.

**CHEM-E1200 Integration and Products (10 cr)**

**Responsible teacher:** Olli Dahl

**Level of the Course:** Master’s level

**Teaching Period:** I-II (2nd year)

**Workload:** 270 h in total; Lectures: 10 - 36 h, Project meetings with supervisors:10 h, Project work: 214 - 240 h (includes 5 - 6 reports and internal project meetings), Seminars: 10h

**Learning Outcomes:**

After the course the student can

1. realize why we need bioproducts and recognize most significant bio-based products and their properties
2. understand market mechanism and dynamics of the products
3. understand impact of the raw material properties on final product quality
4. describe principles of process integration, e.g. understand role of side streams and wastes as a raw material for new products
5. plan, create and estimate sustainable value chains to produce value added products and estimate the sustainability of the existing biorefinery processes
6. form mass and energy balances for the processes
7. evaluate economy of the processes (capital investment, operating cost, production cost, profitability and financial planning, legal aspects)
8. evaluate environmental impacts of the processes and products (LCA calculations, emissions, efficiency, raw materials, transportation, climate change, legal aspects)
9. evaluate societal impacts of the biorefineries (supply chain, social innovation, labor practices, health and safety and legal aspects)
10. work as a member of a team (clear oral and written presentations, management and leadership skills)

**Content:** A pre-feasibility study of a biorefinery process for certain value added products, which is carried out as a group design project. Understanding the mechanisms in the prevailing oil era markets and find out solutions and products to boost the bioeconomy. Plan integral processes and estimate the sustainability of the existing and planned new biorefinery concepts. Sustainability assessment covers economic, environmental, societal, and juridical aspects.

**Assessment Methods and Criteria:** Reporting, peer-assessment

**Study Material:** To be announced later

**Course Homepage:**

**Prerequisites:** For the successful performance of the course CHEM-E1200 students have to have the same knowledge than listed in the following courses: CHEM-E1110, CHEM-E1100, CHEM-E7100, CHEM-E7110, CHEM-E3140 and CHEM-E1150.

**Grading Scale:** 0-5

**Language of instruction and studies:** English

**CHEM-E2100 Polymer Synthesis (5 cr)**

**Responsible teacher:** Mauri Kostiainen
**Level of the Course:** Master's level

**Teaching Period:** I

**Workload:**
- Lectures 20 h
- Learning diary / Exercises 20 h
- Project work 80 h
- Other independent studying 15 h

**Learning Outcomes:** After the course the student can identify and separate the most important ideal mechanisms of polymerisations
- is able to explain basics of initiation and catalysis
- is able to explain the formation of polymer structures and ways to affect them
- can apply theories of step and chain polymerizations
- is able to use theory of copolymerization

**Content:** The course deepens the knowledge in the field of polymer synthesis, purification and analysis. Polymerisation mechanisms, stepwise synthesis of branched polymers and biological synthesis of biopolymers are discussed.

**Assessment Methods and Criteria:**
- Lectures and discussions
- Exercises and group work
- Project work
- Assessment is based on exercises, project work and the exam.


**Substitutes for Courses:** KE-100.3200 Polymer Synthesis

**Course Homepage:**

**Grading Scale:** 0-5

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

**CHEM-E2105 Wood and Wood Products (5 cr)**

**Responsible teacher:** Mark Hughes
**Level of the Course:** Master's level

**Teaching Period:** III-IV

**Workload:**
- Lectures 24 h
- Laboratory exercises 24 h
- Project work 67 h
- Other independent studying 20 h

**Learning Outcomes:** After the course the student knows the key anatomical features of wood and is able to differentiate between softwood and hardwood and is able to identify several key commercially important species from their microstructures
- is familiar with the anisotropic structure of wood and is able to describe how the anatomical structure of wood affects its physical and mechanical properties
- knows the states of water in wood and is able to describe how it affects the mechanical and physical properties of wood
- is familiar with the relationship between cell wall density, bulk density and void volume (porosity) and can apply this information to predict how fluids may behave in wood
- is familiar with the thermal characteristics of wood, especially thermal conductivity, heat capacity and diffusivity
- is familiar with the acoustic properties of wood and how this might be utilised in non-destructive testing and construction
- is familiar with the electrical properties of wood
- is familiar with the combustion properties of wood and its fire performance
- knows about the short-term mechanical properties of wood and how structure/anatomy, density and moisture affect these
- is familiar with the long-term behaviour of wood under static and cyclical loading
- is able to describe the key steps in the manufacture of the major wood products (solid wood, wood-based composites and engineered wood)

**Content:** Wood anatomy and structure; wood-water
relationships; wood density and density-volume relationships; fluid flow in wood; thermal properties of wood; acoustic properties of wood; short-term mechanical properties and structure-property relationships; long-term wood properties (creep & fatigue); manufacture of wood products (solid wood, wood-based composites and engineered wood products)

**Assessment Methods and Criteria:**
Lectures 24 h
Laboratory exercises 24 h
Project work 67 h
Other independent studying 20 h

**Study Material:** J.M. Dinwoodie and other material as directed

**Course Homepage:**

**Grading Scale:** 0-5

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

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**CHEM-E2110 Polymer Technology Laboratory Exercises (5 cr)**

**Responsible teacher:** Sami Lipponen

**Level of the Course:** Master's level

**Teaching Period:** I-II

**Workload:**
Intro and seminar 8 h
Exercises 54 h
Independent studying 73 h

**Learning Outcomes:**
- After the course the student is able to work independently in laboratory.
- Is able to draw conclusions based on experimental results: understands how the structure of macromolecules affect e.g. thermal and mechanical properties of polymer materials.
- Knows in practice different processing methods for polymers
- Can analyse experimental results and draw appropriate conclusions
- Can write a technical report

**Content:** The students do experimental work that supports their theoretical studies in polymer technology. They learn about polymerization, polymer analysis, polymer processing and testing. The course consists of 9 laboratory exercises and their reporting. The course ends with a seminar.

**Assessment Methods and Criteria:**
Lectures 2h
Exercise and reporting 128 h
Seminar 4 h

**Substitutes for Courses:** KE-100.3500, KE-100.3510

**Course Homepage:**

**Prerequisites:** Basic concepts of polymer technology.
Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in this course.

**Grading Scale:** 0-5

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

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**CHEM-E2115 Wood Products: Application and Performance (5 cr)**

**Responsible teacher:** Lauri Rautkari

**Level of the Course:** Master's level

**Teaching Period:** IV-V

**Workload:**
Lectures 8-12 h
Exercises 8-12 h
Excursions and/or project work 81-99 h
Other independent studying 20-30 h

**Learning Outcomes:**
- After the course the student knows the key commercial wood products and is familiar with their structure, properties, general performance characteristics and main applications
  - Is able to describe the situations in which particular materials or products should be used
  - Is familiar with the main regulations and standards covering the use of wood and wood products and knows the key product testing standards
  - Knows the carbon storage potential of wood products and is familiar with the principles of life cycle assessment applied to wood products and wood construction
  - Knows about the main physical and biological degradation mechanisms affecting the performance of wood
  - Is familiar with how the durability and other performance characteristics of wood can be enhanced by applying appropriate design principles, preservation treatment, modifying wood and coating

**Assessment Methods and Criteria:**
Lectures 8-12 h
Exercises 8-12 h
Excursions and/or project work 81-99 h
Other independent studying 20-30 h

**Course Homepage:**
CHEM-E2120 Fibres and Fibre Products (5 cr)

Responsible teacher: Thaddeus Maloney
Level of the Course: Master's level
Teaching Period: I
Workload: 5 cr = 135 h
Combination of lectures, reading and project work and 115 h
Self-study for exam 20 h

Learning Outcomes: After the course the student knows about the range of natural fibres and is familiar with their principal areas of application
• understands fibre ultrastructure and morphology
• understands basics of fibre webs and networks.
• is able to describe the key fibre processing operations.
• knows the basics of fiber swelling and fiber/water interactions
• can analyze fibre properties in the laboratory
• has been exposed to case examples of the latest fibre research and development

Content: Fibre types, fibre processing, fibre ultrastructure, fiber/water interactions, fibre analysis methods, fibre research case examples

Assessment Methods and Criteria:
Lectures
Exercises
Project work
Self-study for exam
Study Material: To be announced later
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E2120
Prerequisites: Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in this course.

Grading Scale: 0-5
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E2125 Web-Based Natural Fiber Products (5 cr)

Responsible teacher: Thaddeus Maloney
Level of the Course: Master's level
Teaching Period: III-IV
Workload: 5 cr = 135 h
Lectures, labs and independent reading 115h
Exam preparation 20 h

Learning Outcomes: After the course the student knows about the latest research mentioned phenomena
• knows different paper and board grades and structures
• is able to measure, analyze and characterize the properties of these products
• is familiar with the papermaking unit operations
• knows the basics of pulp rheology
• knows the basic principles of wet end chemistry
• knows about the latest research activities in paper technology
• is able to utilize some simulation and process data analysis tools

Content: The course gives students an overview of the main production operations for producing web-form products, such as paper, tissue and carton board from natural fibres and other raw materials. Unit operations and their key feature will be covered under the production processes. Teaching is mainly based on lectures and class discussions. In some years a mill visit may be arranged. Simulation and process data analysis tools are introduced to aid the diagnostics of important unit processes and product properties.

Assessment Methods and Criteria:
Lectures
Laboratory work

Grading Scale: 0-5
Registration for Courses: WebOodi
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E2125
Prerequisites: Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in this course.

CHEM-E2130 Polymer Properties (5 cr)

Responsible teacher: Jukka Seppälä
Level of the Course: Master's level
Teaching Period: II
Workload: Lectures 24 h
Exercises and demonstrations 12 h
Other independent studying 120 h

Learning Outcomes: After the course the student understands basics of polymer physics
• understands structure hierarchy of polymers
• understands basics of most important methods of polymer analysis
• understands basic theories of polymer rheology
• knows basics of stability and degradation of polymers
• is able to calculate the above mentioned phenomena


Assessment Methods and Criteria: Lectures
Demonstrations
Exercises
Learning Outcomes: After the course the student knows how wood fibres are isolated from the wood 'matrix'
• knows how the key commercially important vegetable fibres are isolated from the plant and processed into intermediate products
• knows how regenerated cellulose fibres are manufactured
• can describe the structure of the lignocellulosic fibre cell wall and knows how the structural organisation of the cell wall affects the key physical and mechanical properties of the fibre
• is familiar with the properties of regenerated fibre and how this can be manipulated
• is familiar with moisture sorption in cellulose-based fibres and how moisture affects the fibre properties
• is familiar with how damage is induced in cellulose-based fibres and its effect upon their properties
• knows about the manufacture of nanocellulose and is able to describe its properties and current and potential application areas
• has knowledge on the chemical structure and reactivity of cell wall components

Content: Isolation of wood and non-wood fibres from the plant material; cell wall structure of lignocellulosic fibres; chemical structure and most common chemical reactions of cell wall components; structure-property relationships of lignocellulosic fibres; sorption behaviour and effect on properties; fibre mechanics and modelling; defects in fibres and their effect on properties; dissolution of cellulose and manufacture of regenerated cellulose; structure and properties of regenerated cellulose; nanocellulose – isolation, characteristics and applications

Assessment Methods and Criteria:
Lectures 30 h
Exercises 20 h
Project work 60 h
Self-study for exam 24 h

Study Material: To be announced later

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E2140

Prerequisites: Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018)
must have been passed before performing any laboratory works in this course.

Grading Scale: 0-5
Registration for Courses: WebOodi

CHEM-E2145 Polymer Reaction Engineering (5 cr)

Responsible teacher: Jukka Seppälä
Level of the Course: Master's level
Teaching Period: III-V
Workload: Lectures 24 h
Home assignments 60 h
Independent studying 20 h
Exam and its preparation 30 h

Learning Outcomes: After the course the student understands the use of reactor calorimeter in polymerization reactors.
Content: Course covers the following topics: basics of polymerization processes, special features of process technology and reaction engineering of polymers, and production processes of most important polymers.
Assessment Methods and Criteria: Lectures, Demonstrations, Home assignments, Other independent studying, Exam

Substitutes for Courses: KE-100.3700, KE-100.3710
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E2145

Prerequisites: Basics of polymer structures.
Grading Scale: 0 - 5
Registration for Courses: webOodi
Language of instruction and studies: English

CHEM-E2150 Interfacial Phenomena in Biobased Systems P (5 cr)

Responsible teacher: Monika Österberg
Level of the Course: Master's and doctoral level
Teaching Period: III-IV
Workload: 5 cr = 135 h
Lectures: 20-24 h
Exercises: 4-8 h
Lab work: 5-10 h
Self-study, including home assignments, laboratory report and studying for exam: 90-110 h

Learning Outcomes: After the course the student recognises the theoretical background and applies it to the biorefinery technology.
Content: Surfaces and interfaces; adhesion, cohesion, wetting and adsorption; surface-active agents; water-soluble polymers and polyelectrolytes; surface modification methods; flocculation and colloidal stability; nanocellulose; inorganic nanoparticles; antifouling. The course will consist of lectures, exercises, home assignments and lab work focusing on application-based problems.
Assessment Methods and Criteria: Exam, exercises, home assignments and lab work.

Everything will contribute to the final grade.

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E2150

Prerequisites: Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in this course.

Grading Scale: 0-5
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E2155 Biopolymers (5 cr)

Responsible teacher: Orlando Rojas Gaona
Level of the Course: Master's level
Teaching Period: III-IV
Workload: Lectures 24 h
Independent studying 79 h
Exam and its preparation 30 h
Learning Outcomes: After the course the student knows the most common natural and synthetic biodegradable polymers.

- can define what is biodegradation and how it is measured
- can describe the synthesis methods of synthetic biodegradable polymers
- knows the application areas and particular requirements of biodegradable polymers

Content: This Graduate level course deals with the general topic of biopolymers. In this context, this is an introductory course in which Biopolymers indicate those derived from renewable resources (bio-based), either biodegradable or non-biodegradable, and polymers derived from non-renewable resources that are biodegradable. It also includes those polymers produced by biological systems such as microorganisms, plants, or animals, or obtained by chemical synthesis. Fundamentals of the physical chemistry are brought to life with examples from such fields as biotechnology, paper science, biomaterials, etc. Topics include Synthetic Biopolymers, Biodegradation, (bacterial) Cellulose, Polypeptides, etc.

Assessment Methods and Criteria:
Lectures
Independent work
Exam

Study Material: To be announced later

Substitutes for Courses: KE-100.4810 Biopolymers (3 cr)

Course Homepage:

Prerequisites: Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in this course.

Grading Scale: 0-5
Registration for Courses: WebOodi

Language of instruction and studies: English

CHEM-E2160 Product Development Practices (5 cr)

Responsible teacher: Jouni Paltakari

Level of the Course: Master’s level

Teaching Period: III-V

Workload:
5 cr = 135 h
Lectures/workshops 26 h
Labs/group work 69 h
Other independent studying 20 h
Exam preparation 20 h

- Learning Outcomes: After the course the student has improved knowledge on the best practices of developing products and managing innovations in modern global companies.
  - is able to apply these practices to the fibre and polymer technology related industries in the development of new products.
  - recognises the chain of events that takes place between assessing an un-met consumer need and delivering a finished product.
  - realises the critical success factors and have an appreciation for the realities of product development in the fibre and polymer technology related industry.
  - is able to apply statistical product design.
  - is able to professionally manage a simple product development project.

Content: Product development principles and drivers. Modern Innovation management: project management, market vs. technology driven approaches, the product lifecycle, R&D organizations, global R&D networks and operations, IPR management, metrics of success. Product development tools: end-user preferences and sensory engineering, statistical product design, principles of scale-up, virtual product design. Fibre product development in practice: best practice examples from fibre products industry. Laboratory exercise; practice product development: understand consumer needs, form and manage a project, apply statistical product design principles, assess success, report results. The course aims to give the students an overview of the best management and engineering practices useful for developing new fibre based products.

Assessment Methods and Criteria:
Lectures
Project work and exercises
Exam

Study Material: To be announced later

Substitutes for Courses: Puu-0.3200 Fibre Product Development Practices (3 cr)

Course Homepage:

Grading Scale: 0-5
Registration for Courses: WebOodi

Language of instruction and studies: English

★ CHEM-E2165 Computer Aided Visualization and Scientific Presentation (3-5 cr)

Responsible teacher: Mauri Kostiainen

Level of the Course: Master's and doctoral level

Teaching Period: V

Workload:
Lectures 4-6 h = 24 h
Project work + documentation 57 h
Optional: Learning diary / Exercises 54 h to get 5 cr.

- Learning Outcomes: After the course, the student knows the basic functions of the given softwares
  - can identify creative and artistic ways of presenting science
  - is able to produce 3D rendered images
  - can produce simple animations
  - can start working on a visualization topic from own study / research field

Content: The course provides basic software tools for visualization, 3D modelling and rendering. The aim is to promote creativeness and artistic way of
presenting science. Special focus is placed on the visualization small organic compounds, biomolecules and their animations. The course uses three free open-source softwares: UCSF Chimera (protein and volume structures), Povray (text-based scene description) and Blender (3D modelling with GUI). Project work is focused to help the students own key points in scientific productions and presentations.

Assessment Methods and Criteria:
Interactive lectures and hands-on computer work
Exercises and group project
Closing seminar with presentations

Study Material:
Softwares: UCSF Chimera, Povray, Blender

Course Homepage:
https://mycourses.aalto.fi/course/search.php?search
=CHEM-E2165

Grading Scale: Pass/fail

Registration for Courses: WebOodi. Maximum number of students to the course is 15. Students will be selected in the order of enrollment.

Language of instruction and studies: English

CHEM-E2185 Wood Specialization Course: A Project Work P V(V) (5-10 cr)

Responsible teacher: Lauri Rautkari
Level of the Course: Master / Doctoral studies
Teaching Period: I, II, III, IV, V
Workload: 5 cr = 135 h, 10 cr = 270 h To be agreed with the responsible teacher. Depending on duration of the project.

Learning Outcomes: Students learn to make a research plan, implement analysis techniques and report the results in compact form (e.g. a manuscript for peer-review journal)

Content: Laboratory work and/or literature work.

Grading Scale: To be agreed with the responsible teacher

Registration for Courses: Registration via WebOodi. Please see WebOodi for registration dates.

Language of instruction and studies: Primarily English. The assessed work may be completed in Finnish or Swedish upon request.

CHEM-E2195 Interfacial Phenomena in Renewable Materials Research Project P V(V) (5-10 cr)

Responsible teacher: Juan Valle Delgado
Level of the Course: Master studies
Teaching Period: I, II, III, IV, V
Workload: To be agreed with the responsible teacher. The workload depends on the number of credits (5-10 cr): up to 135 h (5 cr) for literature review and writing a report, and up to other 135 h (additional 5 cr) for laboratory work.

Learning Outcomes: The aim is to get insight into current research in the area of biobased colloids and renewable nanomaterials, and application of surface sensitive methods to fiber and polymer technology. After the course the student will have deepened his/her understanding in one specific topic and learned how to use some novel surface sensitive methods in practice. The independent work prepares the student for Master’s Thesis project.

Content: Both written and experimental work is included. The amount of written and experimental work differs from project to project and is in relation to the credits earned.

Assessment Methods and Criteria: Written and experimental work are assessed

Study Material: Material supplied in the course

Substitutes for Courses: Puu-0.4200 Research project on Renewable Materials and Puu-0.4220 Surface and Colloid Chemistry of Renewable Materials

Course Homepage:
https://mycourses.aalto.fi/course/search.php?search
=CHEM-E2195

Prerequisites: CHEM-E2150 Interfacial phenomena in Biobased systems Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in this course.

Grading Scale: Fail, 1 – 5

Registration for Courses: Registration via WebOodi. Please see WebOodi for registration dates.

Language of instruction and studies: English

CHEM-E2200 Polymer Blends and Composites (5 cr)

Responsible teacher: Mark Hughes
Level of the Course: Master's studies
Teaching Period: I
Workload:
5 cr = 135 h
Lectures 14 h
Project work and presentation 81 h
Self-study for exam 40 h

Learning Outcomes: After the course the students familiar with the potential of synthetic polymers in composite technology

• knows the role of reinforcement, matrix and interface in a composite system
• knows the principles of load sharing and reinforcement processes in short and long fibre reinforced composites and the influence of fibre architecture on composite properties
• can use simple micromechanical models to predict selected composite properties
• can evaluate the compatibility between polymer and reinforcement/filler systems and is familiar with the main methods of controlling compatibility
• knows the methods to process thermosetting and thermoplastic polymer composites into various products
• can make a literature study and present his/her study orally

Content: Fibre reinforced polymer matrix composites (FRP); reinforcement, matrix and interface; principles of load sharing; stress transfer mechanisms; fibre (reinforcement architecture); thermoset and thermoplastic polymer composites processing; applications for FRPs.
Assessment Methods and Criteria:
Lectures
Project work and presentation
Self-study for exam
Study Material: To be announced later
Substitutes for Courses: KE-100.4100 Polymer Composites
Course Homepage: https://mycourses.aalto.fi/course/search.php?search =CHEM-E2200
Grading Scale: Fail, 1 - 5
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E2210 Product Development - Project Course (10 cr)
Responsible teacher: Jouni Paltakari
Level of the Course: Master’s studies
Teaching Period: I-IV
Workload:
10 cr = 260 h
Lectures 5-10 h
Seminars 10 h
Project work 200 h
Self-study 40-45 h

• Learning Outcomes: After the course the student is able to manage in engineering work situation where you need to find a proper solution for a problem in a limited time.
  • Can utilise core and advanced knowledge in designing a product.
  • Is able to utilise information search tools and other methods.
  • Is able to use skills in critical/creative thinking and problem solving.
  • Has deeper understanding on the role of professional ethics and responsibility.
  • Has improved the skills in time and resource management, and in team working
  • Is able to act in basic leadership and project management situations.
  • Has improved his skills in written communication, visualization, oral and graphical presentation.
  • Is able to assess and evaluate on personal, team and peer level and can utilize different feedback styles.

Content: The course uses Problem-Based-Learning, which is supported by theme lectures. The students will be working in teams with real cases and design tasks based on a brief from a company or a research spin-off from academia. The outcome is a new solution or a prototype of a fibre based product. Project work includes several stages such as research, insight, ideation and concept creation. The course targets at teaching a systematic and innovative solution creation for a real customer in a limited time and resources. Workshops on graphical design, contextual design and computer aided design will provide useful tools for the teams during their development work. The progress of each team is controlled by check-point meetings, learning diary and intermediate evaluations. The final outcomes are a concept and prototypes that will be presented and evaluated in the end of the course.

Assessment Methods and Criteria:
Lectures
Project work
Tutoring/Mentoring and reflection
Final design report
Study Material: To be announced later
Substitutes for Courses: Puu-0.4320 Fibre Product Development - Project Course (12 cr)
Course Homepage: https://mycourses.aalto.fi/course/search.php?search =CHEM-E2210
Prerequisites: CHEM-E2160 Product Development Practices, 5 cr Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in this course.
Grading Scale: Fail, 1 – 5

Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E3100 Biochemistry (5 cr)
Responsible teacher: Silvan Scheller
Level of the Course: Master studies
Teaching Period: I
Workload: Total 135h = 5cr
Lectures 24 h
Assignments or excercises 24 h
Other independent studying 83 h
Exam 4 h

Learning Outcomes: After the course the student has the ability to:
1. Give a detailed account of the main metabolic and catabolic pathways and homeostasis from a biochemical-enzymology point of view.
2. Describe the function and components of major metabolic pathways and cell energetics to the larger biochemical system of the cell
3. Select methods for the determination of structure and function of enzymes, enzyme catalysis and protein modification
4. Apply the above knowledge in applications for biotechnical production, health-technology applications, and bioscience research.

Content: This course presents a holistic approach to deep scientific and technical understanding of biochemistry. The core contents are energy metabolism, glycolysis, glycogen metabolism, signal transduction, transport through membranes, citric acid cycle, electron transport and oxidative phosphorylation, alternate pathways of carbohydrate metabolism, photosynthesis, synthesis and degradation of lipids metabolism, amino acid metabolism, energy metabolism, integration and organ specialization, and nucleotide metabolism. Examples of enzyme function in carbohydrate hydrolysis and modification.

Assessment Methods and Criteria: The course consists of lectures, excercises and a writted exa., the exam is 75% of the grade and 25 of the grade is obtained by approved completion of assignments or excercises within the set deadlines.
Study Material: To be announced later
Course Homepage: https://mycourses.aalto.fi/course/search.php?search =CHEM-E3100
Prerequisites: CHEM-A1300 Biochemistry, CHEM-C2300 Cell and Molecular Biology, CHEM-C2310 Bioprocess Technology, or equivalent
Grading Scale: Fail, 1 – 5 grading is based on assignments (25%) and exam (75%)
Registration for Courses: WebOodi
Language of instruction and studies: English
Further Information: Professor Silvan Scheller silvan.scheller@aalto.fi

★ CHEM-E3110 Biolab I (5 cr)

Responsible teacher: Heli Viskari
Level of the Course: Master studies
Teaching Period: I
Workload:
Total 135h = 5 cr
Laboratory and other experimentation appr. 75 h
In addition:
Lectures
Reporting (written and oral)
Assignments and self-study

Learning Outcomes: After the course the students
1. have sound theoretical knowledge about methods used in biotechnology laboratories
2. have a good understanding of relevant regulations and safety aspects when working in biotechnology laboratories
3. will be able to perform basic microbiology and biochemistry laboratory experiments
4. will be able to plan and conduct basic experimental work by themselves

Content: This course provides the theoretical background and basic practical skills required for working in biochemistry and microbiology, use of aseptic technique in the laboratory, culturing pro- and eukaryotic cells, isolation, identification and microscopy of the cells, working with proteins and performing analytics with different instrumentation.

Assessment Methods and Criteria:
Experimentation, planning, practical implementation, assignments, reporting.

Study Material: To be announced later
Course Homepage: https://mycourses.aalto.fi/course/search.php?search =CHEM-E3110
Prerequisites: Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in this course.
Grading Scale: Fail, 1-5. Grading is based on attendance, completion of the laboratory experiments and reporting of results and other assignments.
Registration for Courses: WebOodi
Language of instruction and studies: English
Further Information: Priority is given to the degree students in Biotechnology major. If there is space, other students (Aalto degree students and exchange students in Biotechnology major. If there is space, that students have sufficient background knowledge in cell biology and biosciences and microbiology, by using selected case-examples. This is a M.Sc. level course that will not cover the basics of cell structure and function. It is expected that students have sufficient background knowledge of the basic structure and function of pro- and eukaryotic cells.

Assessment Methods and Criteria: The course consists of lectures and assignments that are available in the electronic course materials. Assessment is based on points obtained from the 1) written examination (80%) and 2) the electronic assignments (20%).

Study Material:
Pearson Mastering Microbiology, electronic materials with electronic textbook provided for students: Brock, Biology of Microorganisms. Students will get free access to the electronic textbook and the electronic assignments. No need to buy the book.
Course Homepage: https://mycourses.aalto.fi/course/search.php?search =CHEM-E3120
Prerequisites: Recommended CHEM-C2300 Cell and Molecular biology or equivalent; CHEM-E3100 Biochemistry or equivalent (can be ongoing). Note that a good level of understanding of cell biology is necessary.
Grading Scale: Fail, 1 – 5 grading is based on

CHEM-E3120 Microbiology (5 cr)

Responsible teacher: Katrina Nordström
Level of the Course: Master studies
Teaching Period: I
Workload:
Total 135h = 5cr
Lectures 24 h
Assignments 30 h
Other independent studying 77 h
Exam 4 h

Learning Outcomes:
After the course the student has the ability to:
1. present the structure and physiology of pro- and eukaryotic micro-organisms
2. list the principles of cell growth and underlying intrinsic and extrinsic factors which influence microbial growth including adaptation and sensing
3. describe human - microbe interactions, cell-cell interactions, pathogenicity and antimicrobial control measures
4. present examples of the application of micro-organisms in industry and related applied microbiology

Content: The course deepens the students’ previous knowledge in cell biology and biosciences by providing a more detailed view into systematic and applied microbiology. The focus is on selected microbes only, mainly bacteria, with some general topics on viruses and eukaryotes. The course aims at illustrating the interactions between humans and microbes, the growth environment and parameters influencing growth, in view of understanding microbial physiology and interactions. The course covers biomedical food and applied aspects of microbiology, by using selected case-examples. This is a M.Sc. level course that will not cover the basics of cell structure and function. It is expected that students have sufficient background knowledge of the basic structure and function of pro- and eukaryotic cells.

Assessment Methods and Criteria: The course consists of lectures and assignments that are available in the electronic course materials. Assessment is based on points obtained from the 1) written examination (80%) and 2) the electronic assignments (20%).

Study Material:
Pearson Mastering Microbiology, electronic materials with electronic textbook provided for students: Brock, Biology of Microorganisms. Students will get free access to the electronic textbook and the electronic assignments. No need to buy the book.
Course Homepage: https://mycourses.aalto.fi/course/search.php?search =CHEM-E3120
Prerequisites: Recommended CHEM-C2300 Cell and Molecular biology or equivalent; CHEM-E3100 Biochemistry or equivalent (can be ongoing). Note that a good level of understanding of cell biology is necessary.
Grading Scale: Fail, 1 – 5 grading is based on
assignments (20%) and exam (80%). Assignments must be completed according to the required deadlines, and failure to comply with deadlines will result in forfeiting the 20% for the final grading.

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English. Exams can be completed in English, Finnish of Swedish, but the exam questions will only be given in English.

**CHEM-E3130 Biolab II (5 cr)**

**Responsible teacher:** Tero Eerikäinen

**Level of the Course:** Master studies

**Teaching Period:** I II

**Workload:**
Total 135h = 5cr
Introductory lectures 4 h
Laboratory and other experimentation 85 h
Planning, entry test 21 h
Reporting (written and oral) 25 h

**Learning Outcomes:** The students will be able to
1. design, carry out, analyze and report experimental procedures in wet-lab regarding biological phenomena and bioprocesses
2. interpret certain metabolic pathways and adapt methods to analyze and engineer those for novel products and for better efficiency
3. apply modern techniques of measurements, analysis, and control at different levels of examinations (molecular, single cell, population, reactor, process, plant)
4. master practical application of common equipment to produce and apply biotechnical materials and compounds (cells and enzymes and their products)
5. apply their theoretical knowledge and practical skills to develop processes and products and solve typical problems related to these

**Content:** The objective of the course is to give an overall picture of fermentation in laboratory and pilot scale. The course has two laboratory works: 1) Laboratory-scale fermentation of a recombinant protein, protein purification and protein analysis. 2) Pilot scale fermentation of a sugar alcohol and downstream processing. The students will learn how to use different laboratory equipment for fermentation, downstream processing, quantification of processes, and protein purification with various analyses.

**Assessment Methods and Criteria:** Experimentation, planning, practical implementation, reporting. Some of the topics can be integrated in working in a research group of the Department.

**Study Material:** To be announced later

**Substitutes for Courses:** To be announced later

**Course Homepage:** [https://mycourses.aalto.fi/course/search.php?search=CHEM-E3130](https://mycourses.aalto.fi/course/search.php?search=CHEM-E3130)

**Prerequisites:** CHEM-E3110 Biolab I, CHEM-E3100 Biochemistry, CHEM-E3120 Microbiology Laboratory safety course CHEM-A1010 or CHEM-E0140 (or, alternatively, occupational safety section, which has been taught courses CHEM-A1000 or CHEM-E0100 before the academic year 2017-2018) must be completed before starting the laboratory work.

- **Grading Scale:** The course is graded 1 – 5. There are 100 points divided in the course in the following areas/Activity and attendance in the laboratory 30
  - Laboratory work diary 15
  - Reports 30
  - Seminar presentation 10
  - Entry exam 15

**Registration for Courses:** WebOodi not later than in week 41. Materials are given and groups are divided in week 42.

**Language of instruction and studies:** English

**Further Information:** Only available for students majoring in Biotechnology, not available as an elective for other majors.

**CHEM-E3140 Bioprocess technology II (5 cr)**

**Responsible teacher:** Sandip Bankar

**Level of the Course:** Master studies

**Teaching Period:** II

**Workload:** 5 cr = 135 h
Lectures 14 h
Calculation exercise 8h
Group work 43 h
Independent study and examination 60 h

**Learning Outcomes:** On successful completion of this course, students should be able to
- Analyze the bioprocess development and apply it for commercial interest
- Construct and interpret the bioprocess parameters in bioreactor
- Describe and distinguish between separation techniques of soluble and insoluble products during downstream processing
- Design a bioprocess starting from fermentation to final purification
- Present the importance of bioprocess technology to a group of audience and appreciate the importance of group work

**Content:** Introduction to bioprocess technology, microbial growth and product formation kinetics, process scale up and design, bioreactor operation consideration, material and energy balance in fermentation system, common stages and strategies of bio-separation, design and control of bioprocess parameters

**Assessment Methods and Criteria:** Lectures, exercises, assignments, group work and examination

**Study Material:** Reference books
Michel L. Shuler and Fikret Kargi, Bioprocess Engineering, Basic Concepts, third edition, Prentice Hall PTR
Pauline M. Doran, Bioprocess Engineering Principles, second edition, Academic press
Recent review and research articles

**Substitutes for Courses:** To be announced later.

**Course Homepage:** [https://mycourses.aalto.fi/course/search.php?search](https://mycourses.aalto.fi/course/search.php?search)
Learning outcomes: After the course the students
1. can use methods used in molecular biology laboratories
2. can genetically modify pro- and eukaryotic expression hosts
3. know and can apply methods for screening and selection
4. will be able to plan and conduct basic experimental work by themselves

Content: The course builds on a sound knowledge of cellular components and pathways and aims at how these components and pathways can be genetically engineered in order to create new or improved versions. Targeted and random approaches for creating modifications at the DNA level and strategies for identification and selection of improved biocatalysts and cellular systems are covered. The course provides the theoretical background and practical skills.

Assessment Methods and Criteria: Experimentation, planning, practical implementation, reporting and assignments

Study Material: To be announced later

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E3160

Prerequisites: CHEM-E3110, CHEM-E8120 and CHEM-E8115 Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in this course.

Grading Scale: Fail, 1 – 5. Grading is based on attendance, completion of the experimental work and reporting of results and assignments.

Registration for Courses: WebOodi

Language of instruction and studies: English

Further Information: Priority is given to the degree students in Biotechnology major. If there is space, other students (Aalto degree students and exchange students) with sufficient background in chemistry and biology can be admitted to the course. After the registration period the teacher of the course will
networks can be deduced from a global analysis of cells using -omics tools (transcriptomics, proteomics and metabolomics) and other experimental approaches. Methods and strategies for acquisition and analysis of high throughput data will be discussed. Computer exercises will be used to combine theory with the practice. Modeling of metabolic fluxes, their control and thermodynamic balances are practiced. Programs helping in the interpretation of high throughput data will be used.

**Assessment Methods and Criteria:** Lectures, computer exercises, assignments and independent studying

**Study Material:** Material to be announced

**Course Homepage:** https://mycourses.aalto.fi/course/search.php?search=CHEM-E3170

**Prerequisites:** CHEM-E8120 Cell biology

**Grading Scale:** Fail, 1 – 5 grading is based on exam (70%) and computer exercises and assignments (30%).

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

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**CHEM-E3205 Bioprocess optimization and simulation (5 cr)**

**Responsible teacher:** Tero Eerikäinen

**Level of the Course:** Master studies

**Teaching Period:** I

**Workload:** Total 135 h = 5cr

Lectures and exercises 24 h, 2x2 h per week

Experimental work 15 h

Assignments 12 h

Independent studying 80 h

Exam 4 h

**Learning Outcomes:**

1. build kinetic simulation models of the cell growth and product formation
2. connect different models together to build a bioprocess model
3. define parameters for kinetic and static bioprocess models
4. create experimental designs for bioprocess screening and optimization tests
5. create response surface models and define optimum variable values thereof
6. create multivariate models from various data
sources including e.g. raw materials, cultivation conditions, product properties, expression data 7. utilize certain chemometric modelling approaches for bioprocess estimation and simulation simulations 8. arrange simple experiments to find out certain kinetic and optimization parameters of a bioprocess 9. estimate the model validity in various cases


Assessment Methods and Criteria: Lectures, computer exercises, experimental work, assignments and independent studying

Study Material: Material to be announced

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E3205

Prerequisites: CHEM-E3130 Biolab II or similar Laboratory safety course CHEM-A1010 or CHEM-E0140 (or, alternatively, occupational safety section, which has been taught courses CHEM-A1000 or CHEM-E0100 before the academic year 2017-2018) must be completed before starting the laboratory work.

Grading Scale: Fail, 1 – 5 grading is based on exam (75%) and exercises and assignments (25%).

Registration for Courses: WebOodi

Language of instruction and studies: English

Further Information: Only available for students majoring in Biotechnology, not available as an elective for other majors.

Level of the Course: Master studies
Teaching Period: V
Workload:
Total 135 h = 5cr
Project work on given assignments
Exam
Final seminar
Other independent studying (online lectures and materials)

Learning Outcomes:
After the course the student has the ability to:
1. describe classes of cells with potential for use for cell-based and tissue-engineering products
2. present culturing techniques, growth requirements in vivo and in vitro, and selected bioreactors
3. discuss choices and materials for scaffolds
4. present the product development process of selected products and the key safety and ethical issues

Content: Cell and tissue engineering and case examples of products. Stem cells and their properties. Function of the ECM, scaffolds and growth in2D and 3D including bioreactors. Control of contamination, safety, efficacy and ethics.

Assessment Methods and Criteria: Projects in groups. Grading is based on written examination (50%) and project work (50%). Project work should be allocated some 5 hours /week on average. There is a home exam based on a textbook and selected online materials (to be announced in My Courses).

Study Material: To be announced.

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E3225

Prerequisites:
CHEM-E3100 Biochemistry, CHEM-E3120 Microbiology or equivalent

Grading Scale: Fail, 1 – 5 grading is based on projects (50%) and exam (50%)

Registration for Courses: WebOodi. Max 25 students. No late registration accepted. Students will be admitted to the course in order of registration. Due to space limitations, only available for students in the Biotechnology or Biosystems-

and materials major. Students with minor in 1. Biotechnology, 2. exchange/visiting students are accepted only if there is space in the order specified.

Language of instruction and studies: English

Further Information: Can be taken in year 1 or year 2, providing that prerequisites are fulfilled.

★ CHEM-E4100 Laboratory projects in chemistry (10 cr)

Responsible teacher: Kari Laasonen

Level of the Course: Master studies

Teaching Period: I-III

Workload: Laboratory work 135 h

Data analysis and reporting 135 h

Learning Outcomes: After the course the student knows new synthesis routes and is able to use common instrumentation in chemistry.

Content: The student learns practical laboratory work through chemical synthesis and analysis and by measuring the properties and dynamics of chemical systems.

Assessment Methods and Criteria: Laboratory work, laboratory reports

Study Material: Work instructions given before the lab work

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E4100

Prerequisites: Compulsory Bachelor’s degree chemistry courses. Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in this course.

Grading Scale: Fail, 1-5

Registration for Courses: WebOodi

Language of instruction and studies: English

CHEM-E4105 Nanochemistry and Nanoengineering (5 cr)

Responsible teacher: Mady Elbahri

Level of the Course: Master studies
Learning Outcomes: After the course the student
1. masters the basic principles of green nanotechnology, nanochemistry and nanoengineering
2. has an overview of state-of-the-art synthesis techniques of advanced nanomaterials and new-material design of the desired functions
3. is able to analyze physical property relations in functional materials
4. is able to apply methods/approaches/ideas from scientific papers to own study topics related to materials chemistry

Content: The course covers new-material design, synthesis and on-demand tailoring tools as well as advanced applications of nanomaterials (inorganic, polymeric, nanocomposites) in different forms.

Assessment Methods and Criteria: Lectures, labs, seminar presentations, home problems, and final oral examination.

Study Material: As agreed
Substitutes for Courses: KE-35.6500 Systematic Material Design

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E4110

Grading Scale: Fail, 1–5
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E4110 Quantum mechanics and Spectroscopy (5 cr)

Responsible teacher: Lauri Partanen
Level of the Course: Master studies
Teaching Period: III
Workload: Contact teaching 35-55h
Independent studying 76-96h
Exam 4h

Learning Outcomes:

After completing the course, regarding
I The fundamentals of quantum mechanics the student
- deepens his/her understanding of the central quantum mechanical concepts and phenomena like the Schrödinger equation, the wave function, quantization, the Heisenberg uncertainty principle, and spin. He will also be able to apply these concepts at both the quantitative and qualitative levels to problems in chemistry.

II The structure of atoms and molecules the student can
- utilize simple quantum mechanical models (i.e. particle-in-a-box, harmonic oscillator, quantum mechanical rigid rotor), to model the behavior of particles and can apply these models to treat spectroscopical phenomena.
- describe how quantum mechanical principles manifest in atomic structure and the periodic table based on the simplest atomic model (the hydrogen atom).
- explain how chemical bonds form in simple systems based on modern quantum mechanical theories of chemical bonding (the molecular orbital theory). The student can contrast this model with the previously learned descriptions of chemical bonding and is familiar with the inadequacies of those models.

III Spectroscopy the student
- knows the principles of rotational, vibrational and electronic spectroscopy and can apply the quantum mechanical picture of atoms and molecules to describe the interactions between matter and electromagnetic radiation. The student can categorize different types of spectroscopies based on the range of energies involved.
- becomes familiar with some of the standard spectroscopic databases and can independently seek spectroscopic data. He/she knows how to combine the with quantum mechanical theory to determine properties like bond lengths and dissociation energies.

IV Study skills the student
- obtains better problem solving skills and becomes better equipped to systematically tackle open-ended problems.
- habitudes to studying the lecture material beforehand and can focus their learning on the key parts of the text.

Content: Molecular quantum mechanics, atomic and molecular orbitals, molecular spectroscopy, including rotational, vibrational and XPS spectrosopies.

Assessment Methods and Criteria: Multiform teaching, exercises, project work, exam

Study Material: T. Engel, Quantum chemistry and spectroscopy (Prentice Hall), or Physical Chemistry
Substitutes for Courses: T. Engel, Quantum chemistry and spectroscopy (Prentice Hall), or Physical Chemistry

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E4110

Prerequisites: PHYS-A2140 Structure of Matter (CHEM) or equivalent

Grading Scale: Fail, 1 – 5
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E4115 Computational Chemistry I (5 cr)

Responsible teacher: Kari Laasonen
Status of the Course:
Level of the Course:
Master studies
Workload: Lectures 36 h
Exercises 12 h
Assignments 30 h
Other independent studying 57 h

Learning Outcomes:
After the course the student
1. will know the basics of computational quantum
chemistry. He/she will know the Hartree-Fock theory, some correlation methods and the concept of basis functions.
2. can model various molecules and molecules properties with modern quantum chemistry software.
3. will be familiar with empirical molecular modelling, empirical force fields, molecular dynamics and Monte Carlo methods.
4. can do simulations of simple molecular systems and molecules in water.

**Content:** Basics of molecular modelling. Modelling various types of molecule based materials. Quantum chemical methods focus mostly on modelling of individual molecules. The molecular modelling focuses on interactions between molecules.

**Assessment Methods and Criteria:** Lectures, exercises, assignments

**Study Material:** T. Engel, Quantum chemistry and spectroscopy (Prentice Hall), or Physical Chemistry, C.J. Cramer, Essentials of Computational Chemistry (Wiley) and Andrew Leach, Molecular Modelling: Principles and Applications (2nd Edition), Prentice Hall.

Material given in lectures.

**Course Homepage:**

**Prerequisites:** CHEM-E4110 Quantum mechanics and Spectroscopy or equivalent

**Grading Scale:** Fail, 1 – 5

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

**CHEM-E4120 Quantitative Instrumental Analysis (5 cr)**

**Responsible teacher:** Sakari Kulmala
**Level of the Course:** Master studies

**Teaching Period:** I

**Workload:** Lectures 30 h
Laboratory exercises 16 h
Independent homework 62 h
Exam 3 h

**Learning Outcomes:** After the course the student will be able to

1. describe the theoretical basis of currently important instrumental analysis methods excluding electroanalytical methods.
2. describe the functional components of the instrument/instruments used in the method
3. select suitable methods on the basis of the actual needs (i.e. allowed costs, precision, detection limit, calibration range).
4. find and read basic scientific literature on a given topic related to the novel developments of selected method/method group

**Content:** The course covers the important instrumental methods used in quantitative analysis.

**Assessment Methods and Criteria:** Lectures, exercises, homework and class-room problems and final examination

**Study Material:** As agreed

**Course Homepage:**

**Grading Scale:** Fail, 1-5

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

**CHEM-E4130 Chemistry of the Elements (5 cr)**

**Responsible teacher:** Maarit Karppinen
**Level of the Course:** Master studies

**Teaching Period:** II

**Workload:**
Lectures 30 h
Home problem solving 30 h
Independent homework 72 h
Exam 3 h

**Learning Outcomes:** After the course the student will be able to

1. describe the basic features of the transition metal chemistry
2. derive the basic chemical and physical properties of d-block and f-block transition metals from their electron structures
3. describe the most important compounds of transition elements and name their applications
4. find and read basic scientific literature on a given topic related to the chemistry of elements

**Content:** The course covers the basics of the chemistry of elements. The emphasis is on the d-block transition metals and lanthanoids.

**Assessment Methods and Criteria:** Lectures, seminar presentation, homework and class-room problems and final examination

**Study Material:** As agreed

**Course Homepage:**

**Grading Scale:** Fail, 1-5

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

**CHEM-E4135 Advanced Analytical Chemistry (5 cr)**

**Responsible teacher:** Sakari Kulmala
**Level of the Course:** Master studies

**Teaching Period:** III

**Workload:** Lectures 26 h
Exercises 40 h
Independent homework 40 h
Exam 3 h

**Learning Outcomes:** After the course the student will be able to

1. utilise and treat relatively complicated simultaneous combinations of chemical equilibria.
2. describe the current status of analytical quality systems and general analytical regulations by authorities and scientific community
3. perform validation processes
4. understand and manage the time scale of different patenting routes
5. write simple patent application drafts

**Content:** Treatment of several simultaneous chemical equilibria, current quality systems of analytical chemistry, validation processes and patenting analytical methods and instruments.

**Assessment Methods and Criteria:** Lectures, exercises, homework and class-room problems and final examination

**Study Material:** As agreed

**Course Homepage:**
Further Information: If you have questions regarding the course, please contact Ari Koskinen (ari.koskinen@aalto.fi).

CHEM-E4155 Solid State Chemistry (5 cr)
Responsible teacher: Antti Karttunen
Level of the Course: Master studies
Workload:
Lectures, combined with exercises 32 h
Home problem solving 48 h
Independent project work 55 h
1. Learning Outcomes: After the course the student will be able to
   1. Apply the basic concepts of structural chemistry, such as unit cell, lattice parameters, crystal system, and space group.
   2. Search crystal structures of inorganic solid-state compounds from databases, analyze and visualize the crystal structures.
   3. Analyze bonding in solid state chemistry: Electronegativity, radii and packing of atoms, ligand field theory, band theory.
   4. Describe synthesis methods used in solid state chemistry and read the information given in various phase diagrams.
   5. Analyze information from various structure characterization methods and utilize powder X-ray diffraction data for phase identification.
   6. Describe the roles of crystal defects, doping, and non-stoichiometry.
1. Explain basic structure-property correlations of various inorganic materials.

Content: The course covers all the important electroanalytical methods used in quantitative analysis.
Assessment Methods and Criteria: Lectures, exercises, independent project work
Study Material: As agreed
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E4155
Grading Scale: Fail, 1-5
Registration for Courses: WebOodi
Language of instruction and studies: English
CHEM-E4175 Fundamental Electrochemistry (4 cr)

Responsible teacher: Tanja Kallio
Level of the Course: Master studies
Teaching Period: III

Workload:
4 cr = 108 h
- lectures 24 h
- exam 4 h
- independent study 80 h

Learning Outcomes:
After the course the student will be able to
- understand the thermodynamics in electrolyte solutions
- use simple models for ion-solvent and ion-ion interaction
- use transport equations
- understand the concept of the electrochemical cell

Content: Thermodynamics of electrolyte solutions, Born model, Debye-Hückel theory, the electrochemical cell and structure and capacitance of charged interfaces. The aim of the course is to introduce the utilization of electrochemistry in industrial applications and research, for instance, processing of metals, fuel cells and biomembranes.

Assessment Methods and Criteria: Lectures, homework problems and/or seminar presentation, written or oral examination.

Study Material: Murtomäki, Kallio, Lahtinen, Kontturi: Sähkökemia (in Finnish) and material delivered in lectures.

Substitutes for Courses: A part of the course CHEM-E4145 Electrochemistry (10 cr)

Grading Scale: Fail, 1–5
Registration for Courses: Registration via WebOodi. Please see WebOodi for registration dates.

Language of instruction and studies: English

CHEM-E4185 Electrochemical Kinetics (6 cr)

Responsible teacher: Lasse Murtomäki
Level of the Course: Master studies
Teaching Period: IV-V

Workload:
6 cr = 162 h
- lectures 24 h
- laboratory work 80 h
- exam 4 h
- independent study 54 h

Learning Outcomes: After the course the student will be able to
- write down the rate law of an electrochemical reaction
- solve the reaction equation and the transport problem associated to it
- understand the most common electrochemical techniques

Content: Electron transfer theory (classical); current-voltage curves, overpotentials, effect of the double layer; reaction mechanisms, hydrogen evolution and oxygen reduction; stationary methods; transient methods, Laplace transform; ultramicroelectrodes, SECM; impedance; Marcus theory

Assessment Methods and Criteria: Lectures, homework problems, written or oral examination, laboratory work.


Substitutes for Courses: A part of the course CHEM-E4145 Electrochemistry (10 cr)

Grading Scale: Fail, 1–5
Registration for Courses: Registration via WebOodi. Please see WebOodi for registration dates.

Language of instruction and studies: English

CHEM-E4195 Selectivity in Organic Synthesis (5 cr)

Responsible teacher: Jan Deska
Level of the Course: Master studies
Teaching Period: IV

Workload: Lectures 24 h
Exercise discussions 8 h
Seminar 8 h
Independent homework 90 h

Learning Outcomes: After the course the student will have deeper understanding on
- polarity & orbital control
- stereoelectronics
- regioselectivity & diastereoselectivity

Content: The course takes up previously reviewed organic transformations and discusses them in the context of regio- and diastereoselectivity. The course will provide the tools to perform the conformational analyses and employ general concepts such as polarity control and orbital control to predict reaction outcomes and relative configurations in C-C and C-heteroatom bond forming transformations. Reactions will include the addition of simple carbon nucleophiles, enolates and P-, S-, and Si-stabilized carbanions to carbonyls and olefinic double bonds as well as cycloadditions and rearrangements.

Assessment Methods and Criteria: Lectures, exercises, seminar presentations

Study Material: Clayden, Greeves, Warren, Wothers, Organic Chemistry; chapters 27, 32-35
Brückner, Harmata, Organic Mechanisms; selected material

Prerequisites: CHEM-E4150 Reactivity in Organic Synthesis or equivalent

Grading Scale: Fail, 1–5
Registration for Courses: WebOodi

Language of instruction and studies: English

CHEM-E4205 Crystallography Basics and Structural Characterization (5 cr)

Responsible teacher: Maarit Karppinen
Level of the Course: Master studies
Teaching Period: I
Workload:
Lectures 24 h
Exercises 12 h
Seminars 10 h
Home problem solving 20 h
Independent homework 65 h
Exam 4 h

1. Learning Outcomes: After the course the student will be able to:
   - describe and apply the principles of probability to predict behavior of molecule groups.
   - formulate molecular driving forces and especially entropy as a driving force in soft materials systems.
   - understand and be able to formulate starting from molecular level perspective the forces that drive molecules to associate, adsorb, and undergo chemical reactions or conformational changes.
   - employ the learned molecular level principles of thermodynamics to e.g. solvation, intermolecular interactions, phase transitions, physical and chemical kinetics, as well as, simple macromolecules in solution.

Content: The course deals with structural characterization techniques of inorganic materials and covers also the basics of crystallography. The emphases are on the various diffraction and spectroscopic methods used for phase identification, crystal structure determination and studies of chemical environment.

Assessment Methods and Criteria: Lectures, homework and class-room problems, seminar presentation and final examination

Study Material: As agreed
Substitutes for Courses: KE-35.4100 Inorganic Chemistry IV
Course Homepage: https://mycourses.aalto.fi/course/search.php?search =CHEM-E4205
Prerequisites: CHEM-E4130 Chemistry of the Elements and CHEM-4155 Solid State Chemistry
Grading Scale: Fail, 1-5
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E4210 Molecular Thermodynamics L (5 cr)

Responsible teacher: Maria Sammalkorpi
Level of the Course: Master / Doctoral studies
Teaching Period: II
Workload:
Lectures 24 h (12x2h)
Exercises 12h-24h
Assignments 12-36h
Other independent studying 51-87h

1. Learning Outcomes: After the course, the student is able to:
   - describe and apply the principles of probability to predict behavior of molecule groups.
   - formulate molecular driving forces and especially entropy as a driving force in soft materials systems.
   - understand and be able to formulate starting from molecular level perspective the forces that drive molecules to associate, adsorb, and undergo chemical reactions or conformational changes.
   - employ the learned molecular level principles of thermodynamics to e.g. solvation, intermolecular interactions, phase transitions, physical and chemical kinetics, as well as, simple macromolecules in solution.

Content: A molecular level, microscopic approach to thermodynamics. Molecular driving forces and especially entropy as a driving force in soft materials systems. Focus on chemical and biological systems such as liquids, surfactants, proteins, and polymers.

Assessment Methods and Criteria: Lectures, exercises, assignments, exam
Course Homepage: MyCourses
Prerequisites: CHEM-C2200 Chemical Thermodynamics or equivalent
Grading Scale: Fail, 1-5
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E4215 Functional Inorganic Materials (5 cr)

Responsible teacher: Maarit Karppinen
Level of the Course: Master studies
Teaching Period: II
Workload: Lectures 30 h
Home problem solving 30 h
Independent homework 72 h
Exam 3 h

1. Learning Outcomes: After the course the student is able to:
   - describe and apply the principles of probability to predict behavior of molecule groups.
   - formulate molecular driving forces and especially entropy as a driving force in soft materials systems.
   - understand and be able to formulate starting from molecular level perspective the forces that drive molecules to associate, adsorb, and undergo chemical reactions or conformational changes.
   - employ the learned molecular level principles of thermodynamics to e.g. solvation, intermolecular interactions, phase transitions, physical and chemical kinetics, as well as, simple macromolecules in solution.

Content: The course provides the students with insights into the various important functional inorganic material families employed in new sustainable energy technologies, conventional electronics and optics, as well as spintronics and other emerging application fields. The course covers among others the superconductive, magnetic, ferroelectric, thermolectric, Li-ion and oxide-ion
conductive and photoactive materials, and also the physical phenomena behind the targeted material functions. The focus is on new materials.

**Assessment Methods and Criteria:** Lectures, exercises, assignments, and final examination

**Study Material:** As agreed

**Substitutes for Courses:** KE-35.4500 Functional Oxide Materials

**Course Homepage:**

**Prerequisites:** CHEM-E4115 Computational Chemistry I or equivalent

**Grading Scale:** Fail, 1–5

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

**CHEM-E4225 Computational Chemistry II (5 cr)**

**Responsible teacher:** Kari Laasonen

**Level of the Course:** Master studies

**Teaching Period:** 2018 - 2019: IV-V Organised next time in the autumn 2020 (period I).

**Workload:** Lectures 36 h
Exercises 12 h
Assignments 30 h
Other independent studying 57 h

**Learning Outcomes:**
After the course the student
1. will be familiar quantum chemical modelling by using density functional theory (DFT)
2. will be familiar of modelling of periodic systems and band structures, surfaces, surface reactions, and interfaces.
3. will be familiar with ab initio molecular dynamics and time dependent DFT.
4. will know the basics of machine learning.

**Content:** Density Functional Theory, quantum mechanical modelling of periodic systems, and surfaces and surface reaction. Ab initio molecular dynamics and the basics of machine learning.

**Assessment Methods and Criteria:** Lectures, exercises, assignments

**Study Material:** Mostly material given in lectures and also C.J. Cramer, Essentials of Computational Chemistry (Wiley).

**Course Homepage:**

**Prerequisites:** CHEM-E4115 Computational Chemistry I or equivalent

**Grading Scale:** Fail, 1–5

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

**CHEM-E4235 Transport processes at electrodes and membranes (5 cr)**

**Responsible teacher:** Lasse Murtomäki

**Level of the Course:** Master/doctoral studies

**Teaching Period:** I

**Workload:** Lectures 24 h
Exercises 12 h
Home problem solving 100 h

**Learning Outcomes:** After the course the student will be able to
1. derive transport equations from the entropy production
2. solve the Nernst-Planck equation in several different cases
3. evaluate and solve transport problems on electrodes
4. solve transport problems in porous, ion exchange and liquid membranes

**Content:** The nature of transport, the theoretical basis of transport equations, transport to electrodes, transport in different types of membranes (ion exchange, neutral and liquid membranes).

**Assessment Methods and Criteria:** Lectures, homework problems


**Substitutes for Courses:** KE-31.4510 Transport Processes at Electrodes and Membranes

**Course Homepage:**

**Prerequisites:** KE-31.4100 Basic Electrochemistry and KE-31.4110 Electrochemical Kinetics or CHEM-E4145 Electrochemistry, or equivalent

**Grading Scale:** Fail, 1–5

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

**CHEM-E4255 Electrochemical energy conversion (5 cr)**

**Responsible teacher:** Tanja Kallio

**Level of the Course:** Master studies

**Teaching Period:** II

**Workload:** Lectures 12 h
Laboratory work 40 h
Home work 80 h
Exam 3 h

**Learning Outcomes:** After the course the student will be able to
1. name the most common Galvanic cell types and applications
2. apply electrochemical theories for understanding the behavior of galvanic cells
3. apply electrochemical analysis methods for investigation of galvanic cells

**Content:** Different type of Galvanic cells are presented. The students get acquainted with the operation of Galvanic cells and with the electrochemical analysis methods used to characterize them.

**Assessment Methods and Criteria:** Lectures, homework problems, laboratory experiments, seminar presentation, written reports, written or oral examination

**Study Material:** As agreed

**Substitutes for Courses:** KE-31.5150 Fuel Cells

**Course Homepage:**
https://mycourses.aalto.fi/course/search.php?search =CHEM-E4255

**Prerequisites:** PHYS-A2120 Thermodynamics (CHEM), CHEM-C2200 Chemical Thermodynamics, or equivalent. Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in this course.
CHEM-E4275 Research project in chemistry I (5 cr)

Responsible teacher: Kari Laasonen
Level of the Course: Master studies
Teaching Period: I, II, III, IV, V
Workload: Depends on the nature of the projects, totally 135 h.

Learning Outcomes: After the course the student will be able to:
1. search for relevant literature on a given topic and critically evaluate scientific articles
2. write a clear and logical literature review
3. draw conclusions from results obtained and from results presented in the literature
4. compare results with the literature
5. present experimental results in a clear and logical way in a laboratory report/seminar

Content: A research project can be an extended laboratory work, molecular dynamics simulation or some other theoretical work. The student becomes acquainted with the project through a literature survey, makes the project and reports it either in the form of a written report or a seminar presentation.

Assessment Methods and Criteria: Literature survey and report, laboratory work and report, seminar presentation

Study Material: As agreed

Substitutes for Courses: KE-31.3120 Special Project in Physical Chemistry or KE-35.5100 Research Project in Inorganic Chemistry

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E4275

Prerequisites: Compulsory Bachelor's degree chemistry courses. Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in this course.

Grading Scale: 0-5
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E4285 Research project in chemistry II (5 cr)

Responsible teacher: Kari Laasonen
Level of the Course: Master studies
Teaching Period: I, II, III, IV, V
Workload: Depends on the nature of the projects, totally 135 h.

Learning Outcomes: After the course the student will be able to:
1. search for relevant literature on a given topic and critically evaluate scientific articles
2. write a clear and logical literature review
3. draw conclusions from results obtained and from results presented in the literature
4. compare results with the literature
5. present experimental results in a clear and logical way in a laboratory report/seminar

Content: A research project can be an extended laboratory work, molecular dynamics simulation or some other theoretical work. The student becomes acquainted with the project through a literature survey, makes the project and reports it either in the form of a written report or a seminar presentation.

Assessment Methods and Criteria: Literature survey and report, laboratory work and report, seminar presentation

Study Material: As agreed

Substitutes for Courses: KE-31.3120 Special Project in Physical Chemistry or KE-35.5100 Research Project in Inorganic Chemistry

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E4285

Prerequisites: Compulsory Bachelor's degree chemistry courses. Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in this course.

Grading Scale: 0-5
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E4295 Asymmetric Synthesis of Natural Products (5 cr)

Responsible teacher: Ari Koskinen
Level of the Course: Master studies
Teaching Period: I
Workload: Lectures 24 h
Seminars 8 h
Home problem solving 20 h
Independent homework 70 h

Learning Outcomes: After the course the student will be able to evaluate and design an asymmetric synthesis for a moderately complex target molecule. The student will be able to evaluate the practical applicability of different strategies (stoichiometric vs catalytic; internal, external vs relayed asymmetric induction). The course will emphasize the synthetic applications to natural products and medicinal chemistry. The student will have deeper understanding on natural products (secondary metabolites), their structures, occurrence, significance, classification, and biosynthesis.


Assessment Methods and Criteria: Lectures, seminar presentation


Substitutes for Courses: CHEM-E4245 Natural Product Chemistry or CHEM-E4125 Asymmetric Synthesis
Prerequisites: CHEM-E4195 Selectivity in Organic Synthesis or equivalent
Grading Scale: Fail, 1 – 5
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E4305 Organometallic Chemistry (5 cr)

Responsible teacher: Jan Deska
Level of the Course: Master studies
Teaching Period: II
Workload: Lectures 24 h
Problem sessions 10 h
My Own Reaction 20 h
Portfolio 30h
Independent homework 50 h

Learning Outcomes: After the course the student will have a basic knowledge about transition metal complexes. Student will be familiar with the geometry and reactivity of complexes. Student will know the most important reactions and their mechanisms.

Content: This course is an introduction to transition metal-mediated organic chemistry. Student will be familiar with the reaction mechanism related to Organometallic chemistry. Student will have understanding of different properties that certain organometallic complexes have: Electron count, basicity, electrophilicity/nucleophilicity, ligand strength/exchange. The main focus will be in homogeneous catalytic systems that are currently used in both academia and industry.

Emphasis will be given to the understanding of properties of organometallic complexes and their interaction with substrates. My own reaction:

Students get their own reaction that they will work through whole course
Portfolio: Will describe the work done in My Own Reaction.

Assessment Methods and Criteria: Lectures, problem sessions; seminar presentation and portfolio
Study Material: Lectures, and suggested parts of:
Substitutes for Courses: KE-4.4120 Organic Synthesis. A part of the course CHEM-E4265 Advanced Synthesis (10 cr)
Prerequisites: CHEM-E4195 Selectivity in Organic Synthesis or equivalent
Grading Scale: Fail, 1 – 5
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E5100 Solid State Materials and Phenomena (5 cr)

Responsible teacher: Jari Koskinen
Level of the Course: Master Studies
Teaching Period: I
Workload: 22 h (5 x 4 h + 1 x 2h): Lectures
4 h (2 x 2 h): Term Paper Presentations & Opponeting
15 h (5 x 3 h): Exercises
40 h: Independent study time
35 h: Term Paper (group project)
15 h + 4 h: Exam preparation + Exam

Learning Outcomes: After the course, the student can
1. Explain electrical, thermal, dielectric and magnetic properties from classical or quantum world viewpoint
2. Calculate the main parameters of the abovementioned properties for different materials
3. Describe the working principles of smart materials in sensors and actuators
4. Ask critical questions about peers’ work and give constructive peer-feedback (opponeting)

Content: The course gives a physico-chemical overview of thermal, electric, dielectric and magnetic properties of solid state materials. Additionally, different types of smart materials (shape-memory alloys, magnetostriuctive & piezoelectric materials, electroactive polymers) are discussed, especially in the view of sensor and actuator applications. The course has also a compulsory Term Paper (group project)

Assessment Methods and Criteria: Active involvement in weekly exercise sessions and lectures, Term Paper and exam all contribute towards the grade.

Study Material:
Handouts, scientific papers
Also, some lectures may follow / go deeper into a topic using other solid-state physics books (such as J. Patterson, B. Bailey: Solid-State Physics - Introduction to the Theory, 2nd Ed., 2010 or R. J. Nauman: Introduction to Physics and Chemistry of Materials or S. Elliott: The Physics and Chemistry of...
CHEM-E5105 Powder Metallurgy and Composites (5 cr)

**Responsible teacher:** Michael Gasik

**Status of the Course:** Functional materials specialty courses

**Level of the Course:** Master studies

**Teaching Period:** I-II

**Workload:**
- 5 cr = 135 h
- Lectures 12 h
- Independent work 120 h
- Exam 3 h

**Learning Outcomes:** Learning of different manufacturing methods of powders.

**Content:** Various metallic, ceramic, carbide powders and materials processing, characterization, pressing and sintering. Manufacturing of composites and their applications.

**Assessment Methods and Criteria:** Lectures (12h). Assessment Methods: Seminar work, examination.

**Study Material:** Handouts

**Substitutes for Courses:** Replaces the course MT-0.4706 Powder Metallurgy and Composite Materials P (5 cr), MT-0.6131 Powder Metallurgy and Composite Materials P, (5 cr).

**Course Homepage:** https://mycourses.aalto.fi/course/search.php?search=CHEM-E5105

**Grading Scale:** Fail, 1 - 5.

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CHEM-E5110 Metallic Materials (5 cr)

**Responsible teacher:** Simo-Pekka Hannula

**Status of the Course:** Compulsory for Functional materials students.

**Level of the Course:** Master Studies

**Teaching Period:** II

**Workload:**
- 5 cr = 135 h
- Lectures 24 h
- exercises 12 h
- laboratory work 18 h
- independent studying 78 h
- exam 3 h

**Learning Outcomes:** The student is able to utilize binary and tertiary phase diagrams and transformation kinetics to design material microstructures with desired properties. He can describe diffusion mechanisms and explain precipitation phenomena as well as the main deformation mechanisms and their restoration. Students understands the main degradation mechanisms of metals.

**Content:** Deformation induced microstructural changes, recovery processes, applications of precipitation hardening, polymorphism of ferrous materials, effects of alloying elements, strengthening mechanisms, stainless and special steels, aluminum and copper. Phase diagrams and heat-treatments. Failure mechanisms.

**Assessment Methods and Criteria:** Lectures, exercises, laboratory works.


**Substitutes for Courses:** MT-0.3111 Solvellettu materiaalitiede (5 op).

**Course Homepage:** https://mycourses.aalto.fi/course/search.php?search=CHEM-E5110

**Prerequisites:** CHEM-E5100 Solid State Materials and Phenomena (5 cr).

**Grading Scale:** Fail, 1 – 5.

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

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CHEM-E5115 Microfabrication (5 cr)

**Responsible teacher:** Sami Franssila

**Status of the Course:** Elective course in the following majors:
- Functional materials
- Advanced materials and photonics
- Micro- and nanosciences
- Biosensing and bioelectronics

**Level of the Course:** Master-level

**Teaching Period:** IV-V

**Workload:**
- 1 hour of lectures/week = 12 h
- 2 hours of exercises/week = 24 h
- Homework for weekly exercises = 75 h
- Preparation for exam = 20 h
- Exam = 4 h

**Learning Outcomes:** The student is able to design fabrication processes for simple silicon microdevices, and able to analyze fabrication processes of complex silicon microdevices.

**Content:** Silicon and thin film materials. Unit processes in microfabrication: lithography, etching, deposition, oxidation, doping, polishing, bonding. Process integration of CMOS and MEMS devices. Cleanrooms, process equipment, yield and reliability. Lab demo.

**Assessment Methods and Criteria:** Exercises and quizzes 60%; exam 60% (bonus possibility). The student must achieve at least 40% of maximum points both in exam and in exercises


**Substitutes for Courses:** S-69.3103 Semiconductor technology II (5 cr), MT-0.6031 Microsystems (3 cr), MT-0.6061 Microfabrication (5 cr).
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E5115
Prerequisites: Useful previous studies: Bachelors-level physics, chemistry, materials science, electronics. Important concepts: crystal structure, unit cell, defects, doping, diffusion, Arrhenius, diffraction. Semiconductor technology a plus.
Grading Scale: 0-5. 60% based on exercises and quizzes; 60% on exam (bonus possibility).
Registration for Courses: WebOodi
Further Information: The course is primarily intended for students majoring in the following subjects: Functional materials
Language of instruction and studies: English
Registration for Courses: WebOodi
The course is primarily intended for students majoring in the following subjects: Functional materials
Language of instruction and studies: English
Further Information: The course is primarily intended for students majoring in the following subjects: Functional materials
Language of instruction and studies: English
Registration for Courses: WebOodi
The course is primarily intended for students majoring in the following subjects: Functional materials
Language of instruction and studies: English
Registration for Courses: WebOodi
CHEM-E5120 Interfaces and Nanomaterials (5 cr)
Responsible teacher: Päivi Laaksonen
Status of the Course: Functional Materials, compulsory
Level of the Course: Master Studies
Teaching Period: I
Workload:
22 h (5 x 4 h + 1 x 2 h): Lectures
4 h (2 x 2 h): Poster Sessions
10 h (5 x 2 h): Exercises
40 h: Independent study
39 h: Poster project
20 h: Exam preparation
Learning Outcomes: Student can combine physical and chemical principles that lead to the characteristics of nanoscale materials. Student understands the origin of self-assembly. Student can deduce how the main properties change with size. Student can analyse the data at basic level.
Content: The course gives a physico-chemical overview of solid and soft nanomaterials, including the following topics:
- Types of nanoscale materials
- Self-assembly of nanomaterials
- Properties of nanomaterials (thermal, electric, magnetic, optic) and their differences to macroscopic materials
The course has also a poster project which includes abstract, pitching and poster presentation.
Assessment Methods and Criteria: Exercises, a compulsory poster project and exam contribute to the grade (scale: fail, 1-5). Additionally, the course has non-graded compulsory elements such as pitching and other poster project related tasks.
Study Material:
- M.F. Ashby, P.J. Ferreira, D.L. Schodek: Nanomaterials, Nanotechnologies and Design
- G. Cao, Y. Wang: Nanostructures and Nanomaterials, Academic Press, 2000
- J. Heinemann, 1993.
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E5120
Prerequisites: BSc
Grading Scale: Fail, 1 – 5
Registration for Courses: WebOodi
Language of instruction and studies: English
CHEM-E5125 Thin Film Technology (5 cr)
Responsible teacher: Jari Koskinen
Status of the Course: Functional materials specially courses
Level of the Course: Master studies
Teaching Period: III
Workload:
5 cr = 135 h
Contact teaching 24 h
Self-study for exercises 78 h
Preparation of exam 30 h + 3 h
Learning Outcomes: After having passed this course the student knows the basic thin film processing methods by using vacuum technology, the basic thin films structure and properties characterization methods. The student is familiar with the dependence of thin films structure and properties to the critical coating parameters. The student can select the most potential methods to produce thin films for wanted applications.
Content: Principles of vacuum technology, surface physics and surface-ion interactions and low pressure plasma. Thin film methods: Physical vapor deposition, chemical vapor deposition, and other plasma. Characterization methods for thin films to determine, structure, composition, and mechanical and optical properties.
Assessment Methods and Criteria: Lectures, active exercises and student presentations during contact sessions, examination.
Substitutes for Courses: MT-0.6021 Fundamentals of Vacuum Technology, Thin Films and Metallurgical Coatings (3 cr), MT-0.6067 Thin Film Technology (5 cr)
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E5125
Prerequisites: Recommended CHEM-E5100 Solid
State Materials and Phenomena and CHEM-E5140 Materials Characterization, laboratory course

Grading Scale: Fail, 1 - 5.

Registration for Courses: WebOodi Students chosen to this course are primarily major students of Functional Materials. If more than 20 students enroll to this course, the number of course participants can be limited. All major students are, however, chosen to the course if enrolled in time.

Language of instruction and studies: English

Further Information: Students chosen to this course are primarily major students of Functional Materials. If more than 20 students enroll to this course, the number of course participants can be limited. All major students are, however, chosen to the course if enrolled in time.

CHEM-E5130 Laboratory Course in Functional Materials, V(V) (5 cr)

Responsible teacher: Sami Franssila

Status of the Course: Masters students in Functional materials.

Functional Materials master students have to choose at least two of the following courses:
CHEM-E5200 Personal Research Assignment in Functional Materials V
CHEM-E5130 Laboratory course in functional materials
CHEM-E5210 Group research assignment V

Level of the Course: Master Studies

Teaching Period: III-V

Workload:
Student selects one lab project from offered projects. Each project:
4 h lectures (introduction and project descriptions)
4 h demonstration
15 h reading scientific papers
10-15 h research Plan
48 h experimental work
10 h analysis of the results
30 h reporting + presenting the results

Learning Outcomes: After the course student can
- understand the challenges in early stage research
- think more scientifically in order to solve problems encountered in experimental research
- make a short research plan around a scientific problem

Content:
Students chooses an experimental lab project from the list of offered lab projects; each project is worth of 5 cr. Projects vary from year to year and from period to period. Student can also make this course twice, i.e. choosing two different lab projects student can get 2 x 5cr.
Projects are offered in periods III, IV and V. Student can only take one project every period.
The lab projects are done in groups of 2-4 students. Weekly tutoring sessions together with all students taking the same project. The lab project topics have previously included e.g. nanorods, graphene, ceramics, diamond-like carbon, electrodeposition, nanosurfaces.

Assessment Methods and Criteria: The lab work is done in groups but reporting is individual. Grade consists of research plan, performance in the lab and report.

Study Material: Handouts

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E5130

Prerequisites: Compulsory previous study requirement: CHEM-E5140 Materials Characterization, laboratory course (5 cr).

Grading Scale: Fail, 1 - 5.

Registration for Courses: WebOodi Priority is given to the degree students in Functional Materials major. If there is space, also other Aalto degree students and exchange students can be admitted to the course if they fulfill previous studies requirements. After the registration period the teacher of the course will inform registered students if they can take the course.

Language of instruction and studies: English

Further Information: The selection of topics varies each year. Projects start in periods III, IV and V. Not all projects are offered in all periods. Student can only do one project per period.

CHEM-E5135 Biomimetic materials and technologies (5 cr)

Responsible teacher: Päivi Laaksonen

Status of the Course: Elective for Functional Materials major and Life Science major students, offered also for Bachelor students

Level of the Course: Master studies

Teaching Period: IV-V

Workload:
Flipped Classroom method is utilized in this course, resulting in the following workload:
12 h contact sessions
56 h Project Work
63 h Individual study (preparation for & reflections of contact sessions, short reports)

Learning Outcomes:
After the course students can
- find correlation between functional natural and synthetic materials on molecular and macroscopic level.
- identify some critical phenomena/structures in natural materials and evaluate their performance and suitability in technological environment.
- apply innovative thinking in materials and products design based on deep understanding of materials structure.

Content:
The course will focus on the basic question of biomimetics: “How to develop better technological solutions by getting inspiration from Nature?” The topics of the course are the following:
- Definition of biomimetics
- Material properties, systems and environments
- Material charts for material selection
- Functionallities obtained by biomimetic solutions, especially at nanoscale

The course contains also a project work in which biomimetic solutions are investigated in material design.

Assessment Methods and Criteria: Course is graded based on individual and group tasks.

Study Material: M.F. Ashby, P.J. Ferreira, D.L. Schodek: Nanomaterials, Nanotechnologies and Design - An Introduction for Engineers and...

**Course Homepage:**

**Grading Scale:** Fail, 1 – 5
**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

**CHEM-E5140 Materials Characterization, laboratory course (5 cr)**

**Responsible teacher:** Roman Nowak

**Status of the Course:** Compulsory for Functional Materials students.

**Level of the Course:** Master Studies

**Teaching Period:** I - II

**Workload:**
5 cr = 135 h

- Contact teaching
- 5 Laboratory works
- Independent work and reporting

**Reporting**

**Learning Outcomes:**
- The student knows the capabilities and limitations of major materials and surface characterization techniques
- The student can select the most proper materials characterization methods for particular sample
- The student can critically evaluate the material characterization methods used in research papers
- The student can perform data analysis on the results obtained in laboratory experiments

**Content:** At this course, the student can exploit most common materials characterization methods to characterize the structure and properties of materials. The student can evaluate the capabilities and limitations of major materials and surface characterization techniques such as: Optical microscopy, nanoindentation, Raman, ellipsometry, XRF, XRD, AFM, TEM, SEM, EDS, WDS, XPS.

**Assessment Methods and Criteria:** Weekly seminars, 5 laboratory projects, written reports, examination


**CHEM-E5145 Materials for Renewable Energy P (5 cr)**

**Responsible teacher:** Michael Gasik

**Status of the Course:** Elective course for Functional Materials (CHEM) and Majors in the Energy Masters, but student with various disciplines are welcome. Offered also for Doctoral students.

**Level of the Course:** Master studies, 1./2. year, also for doctoral studies

**Teaching Period:** III-IV

**Workload:** 5 cr = 135 h

- Workshops
- Group work
- Independent work and reflection
- Projects presentation

**Learning Outcomes:** At the end of this course the students are able to:
- Recognize state-of-the-art materials currently used in renewable energy systems
- Identify common degradation mechanisms in these applications
- Develop new material solutions and eco-design
- Share the expertise of ones field in a heterogeneous team
- Justify material selection with scientific argumentation

**Content:** At this course the students learn how materials behave at circumstances relevant for the renewable energy systems (solar systems, wind turbines, energy storage (fuel cells, batteries) and how material development is performed for this kind of systems taking into account also the requirements of circular economy. The students also have multidisciplinary teams where they develop their thinking by preparing new material solutions and eco-designs for these applications.

**Assessment Methods and Criteria:** Workshops, flip the class room, team tasks and innovation project.

**Study Material:**

Scientific articles and news paper clips.

**Substitutes for Courses:** MT-0.3101 Materiaaliutkimusmenetelmät (5 op).

**Course Homepage:**

**Prerequisites:** BSc Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in this course.

**Grading Scale:** Fail, 1 - 5
**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

**CHEM-E5200 Personal Research Assignment in Functional Materials V(V) (5-10 cr)**

**Responsible teacher:** Sami Franssila

**Status of the Course:**
Masters students in Functional materials. Functional Materials master students have to choose at least two of the following courses:

**CHEM-E5200 Personal Research Assignment in Functional Materials V**

**CHEM-E5130 Laboratory course in functional materials, V**

**CHEM-E5210 Group research assignment V**
Level of the Course: Master-level
Workload: Individual project 135 h (5 cr) or 270 h (10 cr). The work should be performed and final report submitted within 1-4 months from the start of the course and no later than 31st July.

Learning Outcomes:
After the course students can:
- devise a research plan with supervisor
- work independently as a member of an academic or an industrial research group
- write a report in scientific style

Content: Investigation of a functional material related scientific/technical research problem given by the supervisor. Variable topics offered by responsible teachers.

Assessment Methods and Criteria:
Individual project and written report: the performance and independency in the lab, ability to keep up with the agreed timetable and the report affect the grade.
The timetable and more detailed content of the project is agreed with the supervisor of the work. However, the work should be performed and final report submitted within 1-4 months from the start of the work and no later than 31st July.

Study Material: Scientific articles
Course Homepage:

Prerequisites: E5140 Materials Characterization, laboratory course

Grading Scale: Fail, 1-5
Registration for Courses:
WebOodi
Registration open in webodzi all year round. Priority is given to the degree students in Functional Materials major. If there is space, also other Aalto degree students and exchange students can be admitted to the course if they fulfill previous studies requirements. After the registration period the teacher of the course will inform registered students if they can take the course.

Language of instruction and studies: English
Further Information:
The topic must be related to functional materials. Course can be taken twice, with 2 different topics (5 cr. each) or it can be expanded into 10 cr with a single topic.
Projects are available on a running basis throughout the year (see MyCourses).
Projects start whenever student and supervisor agree. Expected duration 1-4 months, including report.
However, the final report must be submitted no later than 31st July.

CHEM-E5205 Advanced Functional Materials P (5 cr)

Responsible teacher: Simo-Pekka Hannula

Status of the Course: Functional materials specially courses
Level of the Course: Master studies, 2nd year, or doctoral studies (given first time in fall term 2015).
Teaching Period: I - II
Workload:
5 cr = 135 h
Contact teaching: lectures + seminar = 28 + 5 h
Independent work 72 h
Exam 30 h

Learning Outcomes: After passing this course the student understands manufacturing, properties and applications of advanced metallic and ceramic functional materials.

Content: New materials, their manufacturing, properties and applications.
Assessment Methods and Criteria: Lectures, literature survey, seminar and exam.
Study Material: Handouts
Course Homepage:

Prerequisites: CHEM-E5100 Solid State Materials and Phenomena (5 cr), CHEM-E5110 Metallic Materials (5 cr).

Grading Scale: Fail, 1 - 5.
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E5210 Group Research Assignment in Functional Materials V(V) (5-10 cr)

Responsible teacher: Sami Franssila

Status of the Course:
Masters students in Functional materials. Functional Materials master students have to choose at least two of the following courses: CHEM-E5200 Personal Research Assignment in Functional Materials V
CHEM-E5130 Laboratory course in functional materials
CHEM-E5210 Group research assignment V

Level of the Course: Master studies, recommended 2nd year.
Teaching Period: I - II
Workload: Contact sessions 5 * 3 h Group project 115 h

Learning Outcomes: Students will work in small groups on a real research or design project. The group will be responsible for project management, actual implementation and results reporting. A seminar is arranged where groups present their findings.

Content: Workshops and Research project
Assessment Methods and Criteria: Group activities, oral presentations and reflective journal.
Study Material: Handouts, scientific articles.
Course Homepage:

Prerequisites: Compulsory courses of Functional materials.

Grading Scale: Fail, 1 - 5.
Registration for Courses: WebOodi
Language of Instruction and Studies: English
Further Information: The course will be offered only with 5 cr.

CHEM-E5215 Materials for Nuclear Power Plants P (5 cr)
Responsible teacher: Simo-Pekka Hannula
Status of the Course: Functional materials specialty courses
Level of the Course: Master studies, 2nd year, also for doctoral studies (lectured first time spring 2016).
Teaching Period: III - IV
Workload: 5 cr = 135 h
- Contact teaching: lectures + seminar 28 + 5 h
- Independent work 72 h
Exam 30 h

Learning Outcomes: On successful completion of the course, students have the basic knowledge and understanding of the materials specialist's disciplines needed when working as a member of nuclear power plant teams.

Content: Reactor physics, interaction of radiation with matter, nuclear reactors, fuel management, life cycle issues, regulations and safety issues, construction materials relevant to nuclear reactors, power plants and nuclear waste management.

Assessment Methods and Criteria: Lectures, literature survey, seminar and exam.

Study Material: Handouts
Substitutes for Courses: MT-0.6171 Nuclear Materials P (5 cr).
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E5215
Prerequisites: CHEM-E5200 Personal Research Assignment in Functional Materials (5 – 10 cr), CHEM-E5210 Group Research Assignment in Functional Materials (5 - 10 cr).
Grading Scale: Fail, 1 - 5.
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E5225 Electron Microscopy P (5 cr)
Responsible teacher: Yanling Ge
Status of the Course: Functional materials specialty courses
Level of the Course: Master studies, 2nd year, doctoral studies.
Teaching Period: I - II

Workload: 5 cr = 135 h
- Teaching 27 h
- Exercises and lab work 10 h
- Independent work, pre-exercises, reports and summaries 98 h

Learning Outcomes: After passed this course the student possess a comprehensive understanding about the morphology, structure, defects, crystal orientation and phase information of materials, as well as the chemical distribution down to atomic resolution. He or she also knows the basic fundamentals of transmission electron microscopy, image formation and image analysis and is also familiar with the sample preparation.

Content: The basis and major applications of image formation, electron diffraction, electron invoked spectroscopy and contrast theory. Applications of scanning and transmission electron microscopy and electron spectroscopy.

Assessment Methods and Criteria: Lectures, pre-exercises, summaries.

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E5225
Prerequisites: Compulsory: CHEM-E5140 Materials Characterization, laboratory course (5 cr)
Recommended: CHEM-E4205 Crystallography Basics and Structural Characterization (5 cr)
Grading Scale: Fail, 1 - 5.
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E6100 Fundamentals of Chemical Thermodynamics (5 cr)
Responsible teacher: Daniel Lindberg
Status of the Course: Compulsory course in Sustainable Metals Processing major.
Level of the Course: Master level
Teaching Period: III-V
Workload:
- Lectures 28 h
- Tutorials 24 h
- Independent studies 42 h

Learning Outcomes: After the course the student can calculate heat and energy balances in industrial reactors and processes, calculate chemical equilibria between gas mixtures and pure substances and knows the energetic relations of chemical reactions, construct and apply various equilibrium and phase diagrams

Content: Thermodynamics of pure substances and energetics of chemical reactions and their reactions with simple gas mixtures. Applications of the developed skills to the industrial applications including heat/energy balances.

Assessment Methods and Criteria:
Lectures
- Tutorials and exercises in a computer class
Project work in groups from a selected topic
Independent study and exam

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E6100
Grading Scale: Fail, 1 – 5
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E6105 Thermodynamics of Solutions (5 cr)
Responsible teacher: Daniel Lindberg
Status of the Course: Compulsory course in Sustainable Metals Processing major.
Level of the Course: Master level
Teaching Period: III-V
Workload:
- Lectures 12 h
- Tutorials 36 h
- Project (home) work 25 h
Independent (group) studies 62 h
Learning Outcomes: After the course the student can:
understand the structure of a thermochemical solver (Gibbs energy minimiser),
evaluate experimental solution data and use the Calphad method,
do equilibrium simulations in multicomponent heterogeneous systems
Content: Thermodynamics of solution phases and their analytical forms in condensed systems, use
and development of analytical descriptions for solution phases, applications of Gibbs energy
minimisation techniques for the chemical simulations.
Assessment Methods and Criteria:
Lectures
Tutorials and guided assessments in a computer
Project work in groups from a selected topic
Independent study and exam
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E6105
Prerequisites: CHEM-E6100
Grading Scale: Fail, 1 – 5
Registration for Courses: WebOodi
Language of instruction and studies: English
CHEM-E6115 Thermodynamics of Modeling and Simulation (5 cr)
Responsible teacher: Daniel Lindberg
Status of the Course: Compulsory course in Sustainable Metals Processing major.
Level of the Course: Master level
Teaching Period: III-IV
Workload:
Lectures 6 h
Tutorials 12 h
Project (home) work 45 h (10 h tutorials + 35 h home)
Independent (group) studies 72 h
Learning Outcomes: After the course the student can:
describe industrial problem as a system in terms of its thermodynamic variables,
use thermochemical properties of systems and their analytical expressions in the simulation of properties
and processes,
alalyse and model experimental data in the calculations of chemical equilibria,
assess experimental data and use the Calphad method
Content: Thermodynamic modelling and simulation project work comprises the use of selected software
and its use in a complex industrial-type application or a specific assessment work.
Assessment Methods and Criteria:
Lectures
Tutorials and guided assessments in a computer
Project work in groups from a selected topic
Independent study and exam
Substitutes for Courses: Replaces MT-0.3212 Materiaalien termodynamika (5 cr).
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E6115
Prerequisites: CHEM-6100 and CHEM-E6105
Grading Scale: Fail, 1 – 5.
Registration for Courses: WebOodi
Language of instruction and studies: English
CHEM-E6130 Metal Recycling Technologies (5 cr)
Responsible teacher: Rodrigo Serna Guerrero
Level of the Course: Master
Teaching Period: II
Workload:
5 cr = 135 h
- lectures 24 h
- lecture preparation, independent study and exam preparation 41 h
- exercises 40 h
- group project 30 h
Learning Outcomes:
After completing the course the student can:
- Define the basic concepts of circular economy and successfully apply them within the field of metallic raw materials production
- Understand the different technological steps of metals recycling
- Systemically link processing technologies to understand the physics of resource efficiency
- Simulate basic examples of industrial symbiosis in metal production from secondary raw materials
Content: At this course, the students get an idea of a basic components of metals recycling technologies. Utilization of secondary raw materials to produce new products by learning the corresponding recycling processes steps including aspects of mechanical pre-processing, pyrometallurgy and hydrometallurgy. The students learn to draw recycling processes with HSC Sim program and evaluate best technologies for various recycling cases.
Assessment Methods and Criteria: Lectures, exercises and group project
Study Material: Will be announced at the opening lecture. Some chapters from “Handbook of Recycling”, UNEP Report on Metal Recycling
Substitutes for Courses: CHEM-E6120 Systems Integrated and Sustainable Metals Production
Course Homepage: MyCourses
Prerequisites: Previous studies in chemistry or (metallurgical) process technology or equivalent can be useful.
Grading Scale: Fail, 1 - 5
Language of instruction and studies: English
CHEM-E6140 Fundamentals of Minerals Engineering and Recycling (5 cr)
Responsible teacher: Rodrigo Serna Guerrero
Status of the Course: Master major Sustainable Metals Processing
Level of the Course: Master level
Teaching Period: I
Workload:
Lectures 24 h
CHEM-E6145 Unit Operations in Mineral Processing and Recycling (5 cr)

Responsible teacher: Rodrigo Serna Guerrero
Status of the Course: Master level major Sustainable Metal Processing
Level of the Course: Master level
Teaching Period: III-IV
Workload:
- Lectures 24 h
- Tutorials 24 h
- Project (home) work 45 h (20 h tutorials + 25 h home)
- Independent (group) studies 38 h
- Exam 4 h

Learning Outcomes:
- After the course the student can
  - Dimension equipment for mineral processing, taking into consideration the technological and economical constraints of each design.
  - Calculate properties of mineral products after processing operations, while considering the technical and economic issues of grade-recovery curves.
  - Apply the principles of unit operations design for mineral processing equipment in the context of metals recycling.
  - Explain the interaction between the various unit operations in a mineral processing plant and the specific purpose of each processing unit.

Content:
- Dimensioning of unit operations equipment used in mechanical processing technologies, including comminution, sizing/classification and concentration. - Flowsheet development for the processing of primary and secondary resources with local constraint.
- Mineral products and pricing
- Sizing and optimum design of equipment
- Project phases, project scheduling and prefeasibility study-level design work

Assessment Methods and Criteria: Compulsory assignments and a written examination

Study Material:
- Lecture notes, Wills: Mineral Processing Technology, Elsevier;
- Worrell and Reuter: Handbook of recycling, Elsevier

Substitutes for Courses: Together with course CHEM-E6125 Environmental Management in Industry (5 op), this course replaces the course MT-0.3401 Kierrätysjärjestelmät (10 op).

Course Homepage:

Grading Scale: Fail, 1 – 5
Study Material: Lecture notes, Wills: Mineral Processing Technology, Elsevier; Worrell and Reuter: Handbook of recycling, Elsevier

Substitutes for Courses: This course can be taken as replacement of either the course MT-0.3406 Kierälyteknikiinan erikoistyöt (5 op) or MT-0.3411 Kierälyteknikiinan laboratoriotyöt (5 op).

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E6155

Prerequisites: CHEM-E6140 Fundamentals of minerals engineering and recycling CHEM-E6145 Unit operations in mineral processing and recycling

Grading Scale: Fail, 1 – 5

Registration for Courses: WebOodi

Language of instruction and studies: English

CHEM-E6160 Fundamentals of Pyrometallurgy (5 cr)

Responsible teacher: Ari Jokilaakso
Status of the Course: Master level major Sustainable Metals Processing
Level of the Course: Master level
Teaching Period: II

Workload:
- Lectures 24 h
- Tutorials and exercises 24 h
- Project work 45 h
- Independent studies 38 h
- Exam 4 h

Learning Outcomes:
- After the course the student can describe the basic processes and technologies in ferrous and non-ferrous metals, and the key processing technologies used for non-ferrous metals,
- know the fundamentals of solidification and different casting technologies,
- know the basic principles of process modelling,
- is able to calculate mass and energy balances as well as perform simple process simulations for industrial production units using computational methods.

Content: The course gives an overview of the most important high-temperature metal making processes. The main focus is on the ferroalloys and steelmaking as well as in the non-ferrous metals. Fundamental principles and technologies will be addressed and computational process modelling will be introduced and practiced.

Assessment Methods and Criteria: Compulsory project work and a written examination.


Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E6160

Grading Scale: Fail, 1 – 5

Registration for Courses: Registration through WebOodi. Please see WebOodi for the registration dates.

Language of instruction and studies: English

CHEM-E6165 Unit Processes in Pyrometallurgy (5 cr)

Responsible teacher: Ari Jokilaakso
Status of the Course: Master level major Sustainable Metals Processing
Level of the Course: Master level
Teaching Period: III-IV

Workload:
- Lectures 24 h
- Tutorials and design of experiments 12 h
- Laboratory work 57 h
- Independent studies 38 h Exam 4 h

Learning Outcomes:
- After the course the student can describe the fundamental sub-processes in the oxidation and reduction processes, their driving forces and constraints, including transport phenomena.
- understand the features of heterogeneous reactions at elevated temperatures, such as slag-matte-metal-gas systems, surface phenomena and fundamentals of fluxing.
- is able to explain the principles of essential pyrometallurgical laboratory techniques and understand the role of experimental work on process development.
- can design and conduct experiments for studying different phenomena at elevated temperatures.

Content: This course goes deeper into metals production processes concentrating on chemical and physical phenomena in the unit process level - the main processes and constraints taking place in the metallurgical operations at elevated temperatures are considered. The emphasis is on oxidation and reduction processes, as well as on surface phenomena and multiphase phenomena (e.g. melting/dissolution, reaction, transport and solidification phenomena) in slag-metal-gas-solid systems. In addition some experimental research techniques for studying phenomena at elevated temperatures are introduced and experiments as well as data analysis will be carried out.

Assessment Methods and Criteria: Compulsory laboratory exercise(s) and learning diary/diaries - Written examination


Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E6165

Prerequisites: - CHEM-E6160 Fundamentals of Pyrometallurgy - Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in this course.

Grading Scale: Fail, 1 – 5

Registration for Courses: Registration through WebOodi. Please see WebOodi for the registration dates.

Language of instruction and studies: English
CHEM-E6180 Fundamentals of Hydrometallurgy (5 cr)

**Responsible teacher:** Prof. Mari Lundström  
**Status of the Course:** Master level major  
Sustainable Metals Processing  
**Level of the Course:** Master level  
**Teaching Period:** I-II  
**Workload:**  
- Lectures 12 h  
- Tutorials and exercises 36 h  
- Process selection case work 48 h  
- Independent studies 39 h  

**Learning Outcomes:**  
After passing the course, student can:  
- describe the basic hydrometallurgical processes and technologies,  
- select leaching, solution purification and recovery methods based on properties of raw materials and the product,  
- evaluate the driving forces of a unit process and its kinetics,  
- knows the basics of flow-sheet modelling and is able to design and dimension a simple system in steady state condition  

**Content:**  
- General flowsheet of a hydrometallurgical process  
- Unit operations in hydrometallurgy  
- Factors affecting operation of unit processes  
- Calculation of mass and energy balances  
- Flow-sheet modeling with HSC Sim  

**Assessment Methods and Criteria:**  
- Lectures  
- Tutorials and exercises in a computer class  
- Process selection case work  

**Course Homepage:**  
**Grading Scale:** Fail, 1 - 5  
**Registration for Courses:** WebOodi  
**Language of instruction and studies:** English  

CHEM-E6185 Applied Electrochemistry and Corrosion (5 cr)

**Responsible teacher:** Prof. Mari Lundström  
**Status of the Course:** Master level major  
Sustainable Metals Processing  
**Level of the Course:** Master level  
**Teaching Period:** III-IV  
**Workload:**  
- Lectures 24 h  
- Tutorials and exercises 12 h  
- Laboratory work including reports 72 h  
- Independent studies 27 h  

**Learning Outcomes:**  
After passing the course student can:  
- apply the mixed potential theory to kinetic and equilibrium evaluations of leaching and corrosion systems,  
- design and conduct electrochemical experiments to measure reaction rates and corrosion rates and corrosion probabilities,  
- dimension a leaching, solution purification and recovery process based on selected aims, such as yield, selectivity or residence time,  
- apply the techniques of materials selection and corrosion engineering to the design of processing equipment.  

**Content:**  
- Applied electrochemistry in hydrometallurgical materials production, oxidation and reduction reactions  
- Electrochemistry of corrosion  
- Experimental design using Modde software  
- Electrochemical research methods, experiments and data analysis  
- Corrosion engineering in process equipment  

**Assessment Methods and Criteria:**  
- Lectures  
- Tutorials and exercises in a computer class  
- Laboratory exercises  
- Corrosion problem-solving cases  

**Course Homepage:**  
**Prerequisites:** CHEM-E6180 Fundamentals of Hydrometallurgy  
**Grading Scale:** Fail, 1 – 5  

**Registration for Courses:** WebOodi  
**Language of instruction and studies:** English  

CHEM-E6195 Unit processes and Systems in hydrometallurgy (5 cr)

**Responsible teacher:** Prof. Mari Lundström  
**Status of the Course:** Master level major  
Sustainable Metals Processing  
**Level of the Course:** Master level  
**Teaching Period:** IV-V  
**Workload:**  
- A problem based course with  
  - Lectures 24 h  
  - Characterization & thermodynamics exercises 24 h  
  - Laboratory work 30 h  
  - Equipment design 24 h  
  - Independent work 33 h  

**Learning Outcomes:**  
After passing the course student can:  
- select unit operations for leaching, solution purification and product recovery so that wanted material stream separations and conversions can be achieved,  
- make laboratory experiments to measure reaction rates and conversions for equipment sizing,  
- calculate mass, energy, momentum and water balances for the equipment,  
- prepare a flow-sheet from raw material to product  

**Content:**  
- Determining properties of a raw material  
- Deciding what to produce from a raw material  
- Thermodynamics of hydrometallurgical unit processes  
- Design and conducting laboratory test series to define equipment size based on reaction kinetics  
- Design of leaching, solution purification and product recovery stages  
- Preparation of a flow-sheet from raw material to product  

**Assessment Methods and Criteria:**  
- Lectures  
- Tutorials and exercises in a computer class  
- Laboratory exercises  
- HSC Sim flow-sheet design
Course Homepage:
https://mycourses.aalto.fi/course/search.php?search
=CHEM-E6195
Prerequisites: CHEM-E6185 Applied Electrochemistry and Corrosion
Grading Scale: Fail, 1 - 5
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E6205 Metallurgical Engineering Project
Work (5 cr)

Responsible teacher: Ari Jokilaakso
Status of the Course: Master level major Sustainable Metals Processing
Level of the Course: Master studies
Teaching Period: IV-V
Workload: Lectures 24 h
Tutorials 24 h
Project (home) work 57 h (incl. 20 h project-focused tutorials)
Independent (group) studies 30 h

Learning Outcomes: After the course the students will be able to:
1. Understand the process of plant design for primary or secondary feed (project work).
2. Create flowsheets with material balances from experimental data.
3. Make the dimensioning of a major piece of equipment in a processing plant.
4. Evaluate CAPEX and OPEX costs for the design and overall feasibility and profitability of the process.
5. Make and evaluate simplified questionnaires and quotations.

Content: - Metallurgical feed materials, products, and pricing
- Sizing and optimum design of equipment
- Project phases, project scheduling and feasibility study-level design work.

Assessment Methods and Criteria: Project work and activity during the process.
Study Material: Lecture notes; Morris et al., Handbook on material and energy balance calculations in materials processing, Wiley (e-book).
Course Homepage:
https://mycourses.aalto.fi/course/search.php?search
=CHEM-E6205
Prerequisites: CHEM-E6160 Fundamentals of Pyrometallurgy, CHEM-E6165 Unit Processes in Pyrometallurgy
Grading Scale: Fail, 1 - 5
Registration for Courses: Registration through WebOodi. Please see WebOodi for the registration dates.
Language of instruction and studies: English

Further Information: If you have completed the course CHEM-E6155 Mineral engineering project work, please, contact the teacher in charge.

CHEM-E6210 Individual Research Project, V(V)
(5-10 cr)

Responsible teacher: Michael Gasik
Level of the Course: Master
Teaching Period: English
Workload: 135 h (5 cr.) / 270 h (10 cr.)

Learning Outcomes:
- The students can plan together with the supervisor a research plan
- The student can independently work with the project under supervision
- The student can present experimental/modelling findings in a written report

Content: Student will work in an individual research project with one of the research groups. This project will include experimental or modelling work related to the topics of Sustainable Metals Production. The student prepares a written document where the project findings are presented.

Assessment Methods and Criteria: Hands on working in a research group, report writing
Study Material: Scientific publications
Substitutes for Courses: --
Prerequisites: Minimum of 3 compulsory courses from the Sustainable Metals Processing Major
Grading Scale: Fail, 1 - 5
Registration for Courses: WebOodi
Language of instruction and studies: English

CHEM-E6215 Circular Economy Design Forum P
(5 cr)

Responsible teacher: Rodrigo Serna Guerrero
Status of the Course: Course is part of Sustainable Metals Production major at CHEM school, however, student with other relevant field are welcome to create a multidisiplinary forum.
Level of the Course: Master Studies/Doctoral Studies
Teaching Period: IV-V
Workload: Workshops 6 * 3 h
Project work 75 h

Individual studying and reflection 42 h

Learning Outcomes: After the completion of the course the student has
- create their own prospective to circular economy and its relevance in the production and processing of metallic raw materials
- developed entrepreneurial thinking from a circular economy perspective
- modeled innovative recycling processes to determine their feasibility and environmental impact
- applied their knowledge to design product/process/service for circular economy, aspects of economic analysis
- worked in a multidisciplinary team

Content: At this course the student conceptualize the role of a circular economy model for the production of raw materials. The students will work in groups and apply an entrepreneurial mind-set to solve an industry relevant project by developing a new process, product or system design and construct a business plan around it. The student groups will present their projects in front of a panel of experts.

Assessment Methods and Criteria: Workshop tasks, group project and peer evaluation
Handouts and scientific articles.

Substitutes for Courses: CHEM-E6135 Planning Exercise in Sustainable Metals Processing
Prerequisites: CHEM-E6130 Metal Recycling Technologies (5 cr) ja CHEM-E6155 Circular Economy for Materials Processing (5 cr), recommended for students in Sustainable Metals
Processing major. For others, a strong background in one’s own field (design, business, engineering, politics).

**Grading Scale:** Fail, 1 – 5

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

**Further Information:** Students from other schools in Aalto are encouraged to participate in the forum, but in that case the teacher will provide additional material to cover the prerequisites. The maximum amount of participants are 40 students and first priority are students from the sustainable metals processing and EMREC.

**CHEM-E6225 Technical Innovation Project (10 cr)**

**Responsible teacher:** Annukka Santasalo-Aarnio

**Status of the Course:** Obligatory course for Sustainable Metals Processing master’s major. Is offered also to other student with strong background on their professional expertise (at least 1 year of master’s studies).

**Level of the Course:** Master Studies, preferable 2nd year.

**Teaching Period:** I – II

**Workload:** Workshops

Innovation group project

Independent study and reflection

Seminar

**Learning Outcomes:**
- The students can recognize his/her expertise by working in a multidisciplinary team
- The student can evaluate added value of process, service or product
- The student learns entrepreneurial mindset towards problem recognition and solving
- The student creates international network of peers and company representatives through network platform

**Content:** Students work in multidisciplinary teams on a real research or design project. The group aims for identifying value added process, service or products. In addition, the workshops enhance student teamwork skills and introduce to entrepreneurial mindset. The projects will be further improved by peer and industry feedback at international network platform.

**Assessment Methods and Criteria:** Workshops, project work and individual reflection

**Study Material:** Handouts

**Substitutes for Courses:** CHEM-E6200 Materials Processes and Synthesis (10 cr)

**Prerequisites:** BSc and 1st year of master’s studies on student own field

**Grading Scale:** Fail, 1 – 5

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

**Further Information:** The participation is recommended at the end of master’s studies.

**CHEM-E6235 Circular Economy for Materials Processing (5 cr)**

**Responsible teacher:** Rodrigo Serna Guerrero

**Status of the Course:** Sustainable Metals Processing major

**Level of the Course:** Master

**Teaching Period:** III - IV

**Workload:**
- 135 h (5 cr.)
- Contact teaching 27 h
- Independent and group tasks 108 h

**Learning Outcomes:**
- The students can identify the different stakeholders in the circular economy and their particular roles
- The student has methods to evaluate sustainability of materials and processes
- Enhancing sustainability in the processes for recycling products and materials

**Content:**
- This course connects the different stakeholders, particularly business and consumers into circular economy development. It also provides a systemic approach and cooperation among actors operating in the supply chain with different themes:
  1) The business landscape
  2) The metal producing and recycling industry
  3) Technologies and methods for enhancing sustainability

**Assessment Methods and Criteria:** Contact sessions, MOOCs, group tasks

**Study Material:** Contact session and online material

**Substitutes for Courses:** --

**Course Homepage:** MyCourses

**Prerequisites:** Preference given to students that have taken CHEM-E6130 Metal Recycling Technologies

**Grading Scale:** Fail, 1 - 5

**Language of instruction and studies:** English

**CHEM-E7100 Engineering Thermodynamics, Separation Processes, part 1 (5 cr)**

**Responsible teacher:** Marjatta Louhi-Kultanen

**Status of the Course:** Compulsory course in Chemical Engineering major.

**Level of the Course:** Master studies

**Teaching Period:** I

**Workload:**
- Lectures 12 h
- Exercises 36 h
- Homework assignments 40 h
- Other independent studying 45 h

**Learning Outcomes:** After the course the student
- Is able to utilize phase equilibrium data in design of separation processes
- Is able to design unit operations in product purification and solvent recycling
- Is capable of modelling and designing separation processes
- Is capable to apply process simulators in solving mass and energy balances of separation processes

**Content:** Phase equilibria and thermodynamic models of non-electrolyte and electrolyte systems, energy requirements of thermal separation processes, role of unit operations in product purification and solvent recycle, modelling and design of unit operations and process simulation techniques.

**Assessment Methods and Criteria:** Lectures, computer class exercises, mandatory homework assignments, exam

**Study Material:** To be announced later.
Substitutes for Courses: KE-42.3100 Kemian laitetekniikka II a (5 op) or KE-42.3200 Fundamentals of Separation Processes (5 cr).

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E7100

Grading Scale: Fail, 1 – 5

Registration for Courses: WebOodi

Language of instruction and studies: English

CHEM-E7105 Process Development (5 cr)

Responsible teacher: Pekka Oinas

Status of the Course: Elective specialization course in Chemical Engineering major.

Level of the Course: Master studies

Teaching Period: II

Workload: • 135 h in total
  • Lectures 24 h
  • Exercise 12 h
  • Project work 40 h
  • Other independent studying 59 h

Learning Outcomes: After the course the student
  • Understands connection between process development and process design
  • Can apply conceptual design, HSE and LCA principles during process development
  • Can participate in designing laboratory experiments and carry out process modeling and simulation from process development perspective
  • Knows the most relevant IPR and legislation requirements related to chemical process industries
  • Can calculate component mass balance for a complete plant
  • Can clearly present and defend a selected research topic

Content: • Basics of a process development project: contents, project group, timing
  • Laboratory experiments as sources of information for modeling based process design and development
  • IPR in process technology: patents, licensing, trademarks
  • Principles of conceptual design
  • Safety and sustainability issues in process development
  • Case studies from industry
  • Comprehensive calculation exercise

Assessment Methods and Criteria: • Lectures including visiting lecturers from industry
  • Project work in groups focusing on a selected topic
  • Reporting seminar
  • Assignment (calculation exercise (implementation of a process to a plant)
  • Learning log
  • Exam


Substitutes for Courses: KE-42.4120 Process Development P (4 cr) or KE-107.4300 Process design I (3 cr).

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E7105

Grading Scale: Fail, 1 – 5

Registration for Courses: WebOodi

Language of instruction and studies: English

CHEM-E7110 Engineering Thermodynamics, Separation Processes, part 2 (5 cr)

Responsible teacher: Marjatta Louhi-Kultanen

Status of the Course: Compulsory course in Chemical Engineering major.

Level of the Course: Master studies

Teaching Period: II

Workload: Lectures 12 h
  Exercises 36 h
  Homework assignments 40 h
  Other independent studying 45 h

Learning Outcomes: After the course the student
  *is able to take into account simultaneous phase and reaction equilibrium
  *is capable to understand the role of mass transfer for real processes
  *is capable to apply process simulators in solving simple industrial examples

Content: Thermophysical and transport properties, optimization of parameters, simultaneous phase and reaction equilibria, mass transfer and rate based modelling of separation processes, unit operations and separation sequences, simulation.

Assessment Methods and Criteria: lectures, computer class exercises, mandatory homework assignments, exam

Study Material: To be announced later

Substitutes for Courses: KE-42.3110 Kemian laitetekniikka II b (5 op)

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E7110

Grading Scale: Fail, 1 – 5

Registration for Courses: WebOodi

Language of instruction and studies: English

⊗ CHEM-E7115 Experimental Assignment in Chemical Engineering (5 cr)

Responsible teacher: Marjatta Louhi-Kultanen

Status of the Course: Elective specialization course in Chemical Engineering major.

Level of the Course: Master studies

Teaching Period: I - II and III - V

Workload: Lectures 5 h
  Work in laboratory 40 h
  Other independent studying 90 h

Learning Outcomes: After the course the student
  *has hands on experience in experimental laboratory work or simulation or process modelling
  *understands the operation principles of the laboratory scale apparatus
  *is capable of working independently
  *is capable of writing a proper technical report
  *can analyze obtained experimental data and draw
appropriate conclusions

Content: Safety aspects of laboratory work, planning of experiments, running the experiments, analyzing the relevant data, laboratory diary, reporting.

Assessment Methods and Criteria: laboratory exercises, laboratory diary, reporting of experiments

Study Material: To be announced later.

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E7115

Prerequisites: Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in this course.

Grading Scale: Fail, 1 - 5

Registration for Courses: WebOodi Only available for students majoring in Chemical and Process Engineering.

Language of instruction and studies: English

Further Information: The student should pick individual laboratory exercises offered by different research groups according to his/her planned field of specialization.

**CHEM-E7120 Laboratory Project in Chemical Engineering (5 cr)**

Responsible teacher: Juha-Pekka Pokki

Status of the Course: Compulsory course in Chemical Engineering major.

Level of the Course: Master studies

Teaching Period: II

Workload: Lectures 16 h

Exercises 40 h

Home assignments 30 h

Pre-exam 15 h

Other independent study 33 h

Learning Outcomes: After the course the student

- understands the operation principles of the laboratory scale apparatus and its relation to catalyzed chemical reactions as well as phase and reaction equilibrium
- is capable to analyze the compositions of the streams in practice
- is capable of working in group and organizing the work load in a meaningful way

Content: Safety aspects of laboratory work and economic potential of the selected case, comparison of process alternatives, planning of laboratory scale experiments, running the experiments to produce and separate a chemical component, analyzing the composition with the relevant technique, laboratory diary, reporting and seminar presentation.

Assessment Methods and Criteria: lectures, laboratory exercises, laboratory diary, reporting of experiments, seminar presentation

Study Material: To be announced later

Substitutes for Courses: KE-42.3510 Tehdastekniikan laboratoriotyöt (2 op)

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E7120

Prerequisites: Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed before performing any laboratory works in this course.

Grading Scale: Fail, 1 - 5

Registration for Courses: WebOodi

Language of instruction and studies: English

Further Information: Students chosen to this course are primarily major students. If more than 30 students enroll to this course, the number of course participants can be limited. All major students are, however, chosen to the course if enrolled in time. A student cannot have both courses CHEM-E7120 Laboratory Project in Chemical engineering (5 cr) and KE-42.3510 Tehdastekniikan laboratoriotyöt (2 op) in one’s degree. If a student has already taken the course KE-42.3510, the student should do one extra specialization course instead of the course CHEM-E7120 (altogether 4 specialization courses).

**CHEM-E7130 Process Modeling (5 cr)**

Responsible teacher: Ville Alopaeus

Status of the Course: Compulsory course in Chemical Engineering major.

Level of the Course: Master studies

Teaching Period: II

Workload: Lectures 16 h

Exercises 40 h

Home assignments 30 h

Pre-exam 15 h

Other independent study 33 h

Learning Outcomes: After the course the student

- understands the process dynamics and nonlinearities of typical chemical processes and coupling between physical phenomena
- can model chemical processes and carry out model based analysis
- can solve mechanistic process models using appropriate numerical techniques

Content: Dynamical process modeling with material and energy balances

Effect of rate models (mass and heat transfer, reaction rates) on modeling

Specific topics in mass transfer: multicomponent mass transfer, non-conventional driving forces, population balances

Numerical methods to solve typical mechanistic models in chemical engineering including algebraic, ordinary and partial differential equations. Reactor and unsteady heat transfer modeling examples.

Implementation of the models and numerical methods using Matlab/Simulink

Homework assignment: Numeric Solving of differential equations; first principle modelling of process units

Assessment Methods and Criteria: Pre-exam Lectures

Exercises at computer class

Home assignments

Independent study and exam
CHEM-E7135 Reactor Design (5 cr)

Responsible teacher: Yongdan Li

Status of the Course: Elective specialization course in Chemical Engineering major.

Level of the Course: Master studies

Teaching Period: III-IV

Workload:
Lectures 18 h
Project work 72 h
Other independent studying 40 h

1. **Learning Outcomes:** After the course the student is able to describe different phenomena (e.g. reactions and mass transfer) in industrial reactors
   1. combine rate equations and stoichiometry with balance
   2. equations of multiphase reactors
   3. apply mass and energy balances for different industrial multiphase reactors and perform calculations using the balances
   4. explain the principles of computational calculations of multiphase reactors
   5. recognizes the applications of different industrial reactor types
   6. plan a reactor concept for a given industrially relevant reaction system, including selection and use of the simulation model as well as preliminary dimensioning of an industrial reactor

Content:
Must know:
- theories and phenomena behind the mass and energy balances as well as mass transfer in multiphase reactors
- principles of combining rate equations, balance
- equations and stoichiometry
- basic principles of computational calculations
- of multiphase reactors
- how to select the reactor type for a given chemical system

Should know:
- how to implement the reactor mass and energy balances in given simulation software
- how to choose the numerical solving strategies
- for the given reactor model
- how to carry out the preliminary dimensioning
- for given chemical system using computational calculations

Nice to know:
- ways to intensify chemical reactors
- main industrial applications of different reactor types
- derivation of mass and energy balance equations
- from basic theories

Assessment Methods and Criteria: Lectures and a project work. Evaluation based on project work and assignments.

Course Homepage:

Prerequisites: CHEM-E7150 Reaction Engineering

Grading Scale: Fail, 1-5

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**CHEM-E7140 Process Automation (5 cr)**

Responsible teacher: Sirkka-Liisa Jäämsä-Jounela

Status of the Course: Compulsory course in Chemical Engineering major.

Level of the Course: Master studies

Teaching Period: I

Workload: Lectures 24 h
Exercises 24 h
Independent studying, homeworks / preparing for exam 80 h
Exam 4 h

**Learning Outcomes:** After the course the student
- understands the information flows in industrial plants and enterprises
- knows the systems involved in the information handling: automation systems, production and resource planning and controlling systems (MES, ERP, APS)
- understands the most basic functions of an automation system;
- knows functions and tuning methods of a basic controller types: PID, feed-forward, cascade, ratio controllers
- knows how to analyze process dynamics and the dynamics of a system with a controller
- knows the fundamentals of experimental modelling of chemical processes

Content: Automation systems, MES, ERP, APS. Process dynamics, process modelling and identification, classical control theory, single-loop control and controller design.

Homeworks:
- Modeling of heat exchanger
- First principle modeling and model linearization of the 3-tank system
- Feed-forward control of tanks in series

Assessment Methods and Criteria: Lectures
Exercises
Homeworks
Independent study and exam

Study Material: To be announced later.
Learning Outcomes: After the course the student
* Knows the most important systems of the production planning and control used in the process industries, their structure and operation principles;
* Knows the most important operation research areas and their typical problems;
* Is able to use linear programming: Simplex methods and its variants;
* Knows the methods for transportation and networks optimization;
* Knows dynamic programming, integer programming and nonlinear programming methods and their use;
* Knows inventory theory, forecasting and scheduling methods and their use.

Content: The aim of the course is to give knowledge about methods used in production planning and control of industrial processes. Applications of production control are also discussed.

Assignments:
LP optimization of Tennessee eastman
Optimal preventive maintenance of feeding connections of a chemical plant using dynamic programming

Assessment Methods and Criteria: Lectures, exercises, home assignments.

Course Homepage:

Grading Scale: Fail, 1-5

Registration for Courses: WebOodi

Language of instruction and studies: English

CHEM-E7155 Production Planning and Control (5 cr)

Responsible teacher: Sirkka-Liisa Jämsä-Jounela

Status of the Course: Elective specialization course in Chemical Engineering major.

Level of the Course: Master Studies

Teaching Period: I-II

Workload: Lectures 24 h

Exercises 24 h

Home assignments and independent study 80 h

Exam 4 h

Learning Outcomes: After the course the student
* Knows the most important systems of the production planning and control used in the process industries, their structure and operation principles;
* Knows the most important operation research areas and their typical problems;
* Is able to use linear programming: Simplex methods and its variants;
* Knows the methods for transportation and networks optimization;
* Knows dynamic programming, integer programming and nonlinear programming methods and their use;
* Knows inventory theory, forecasting and scheduling methods and their use.

Content: The aim of the course is to give knowledge about methods used in production planning and control of industrial processes. Applications of production control are also discussed.

Assignments:
LP optimization of Tennessee eastman
Optimal preventive maintenance of feeding connections of a chemical plant using dynamic programming

Assessment Methods and Criteria: Lectures, exercises, home assignments.

Course Homepage:

Grading Scale: Fail, 1-5

Registration for Courses: WebOodi

Language of instruction and studies: English

CHEM-E7160 Fluid Flow in Process Units (5 cr)

Responsible teacher: Ville Alopaeus

Status of the Course: Compulsory course in
Chemical Engineering major.

**Level of the Course:** Master studies

**Teaching Period:** IV-V

**Workload:** Lectures 24 h
Exercises 24 h
Assignments + independent study 83 h
Exam 4 h

**Learning Outcomes:** After the course the student
- Knows technical solutions for typical mixing problems
- Can solve fluid flow problems based on material, energy and momentum balances
- Can use modern simulation tools to solve fluid flow problems numerically
- Understands how fluid flow affects process performance and can design processes to ensure proper fluid flow
- Understands the nature of non-Newtonian and multiphase fluid flows

**Content:** Navier-Stokes equations and computational fluid dynamics in single and multiphase systems
Fundamentals of mixing: stirred vessels (gassed, slurred), static mixers, mixing in reactors
Multiphase flow in pipes and process units, settling, fluidization
Fluid flow in porous materials
Practical design of unit operations for controlled multiphase flow
Non-Newtonian flow, rheological property models
Fluid flow measurements

**Assessment Methods and Criteria:** Lectures
Exercises at computer class
Project work in groups from a selected topic
Lectures 24 h
Assignments + independent study 83 h
Exam 4 h

**Learning Outcomes:** After completing the course, the student
- Understands the main principles of the model identification
- Is familiar with the identification toolbox
- Understands and is able to apply Kalman filtering for the state estimation
- Is familiar with the basics of multivariable control
- Knows the discrete time control and is able to formulate and solve dynamic models in discrete time
- Understands and is able to use Model Predictive Control (MPC)

**Content:** The course includes the selected topics of advanced control theory: model identification, state estimation with Kalman filter, multivariable control, discrete time systems and design of digital controllers, model predictive control. The course is focused on multivariate systems.

**Assignments:**
- Identification of the mixing tank
- PI controller and decouplers design for the 3-tank system
- MPC design + state estimation for the three-tank system

**Homeworks:**
- Experimental modelling of a distillation column

**Assessment Methods and Criteria:** Lectures
Exercises
Assignments
Independent study and exam

**Study Material:**
- To be announced later.

**Substitutes for Courses:**
- KE-90.4510 Control Applications in Process Industries (6 op), CHEM-E7145 Advanced Process Control Methods and Process Control Project Work (5 cr)

**Grading Scale:** Fail, 1 - 5

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

**CHEM-E7165 Advanced Process Control Methods (5 cr)**

**Responsible teacher:** Sirkka-Liisa Jämsä-Jounela

**Status of the Course:** Elective specialization course in Chemical Engineering major.

**Level of the Course:** Master Studies

**Teaching Period:** III

**Workload:** Lectures 24 h
Exercises 24 h
Assignments + independent study 83 h
Exam 4 h

**Learning Outcomes:** After the course part A the student
- Acquires advanced practical knowledge on process design and preliminary plant design
- Can make market study of raw materials, products, process alternatives and calc. material margin
- Can calculate material and energy balance and simulation of the process
- Can draw process flow diagram (PFD)
- Can define equipment sizing, equipment list, specification and instructions
- Can demonstrate team work, presentation, management and leadership skills in real plant design

**Content:** 1. A preliminary design and feasibility study of a process, done as a design project. Includes: acquiring of source information for design, methods of design, Project work is done in teams of 5-6 students. The design project in part A is divided into two reports:
2. Project start-up, market study and plant location, process alternatives and comparison of process alternatives
3. Selecting the process alternatives; process design, PFD, material and energy balance, equipment sizing, equipment lists, emissions, environmental and safety of the process

Learning Outcomes:
1. Can acquire the basic knowledge of safety issues and can continue Part B in the same design topic.
2. Can define equipment specification and instructions
3. Can apply out safety (HAZOP) analysis of the process
4. Can calculate capital investment, operating cost, production cost, analyze profitability and financial planning and business model
5. Can demonstrate team work, presentation, management and leadership skills in real plant design

Assessment Methods and Criteria: Project-based learning, lectures and exercises, seminar presentations, group team work and meetings

Study Material: Oinas and Golam, Design project guide

Substitutes for Courses: CHEM-E7200 (partly)

Prerequisites: Advanced knowledge in process and plant design, simulation, costs calculation, safety and business

Grading Scale: Fail, 1 - 5

Registration for Courses: WebOodi

Language of instruction and studies: English

Further Information: After Part A students get 5 cr and can continue Part B in the same design topic.

CHEM-E7175 Process Safety and Sustainability (5 cr)

Responsible teacher: Pekka Oinas
Level of the Course: Master studies
Teaching Period: I-II
Workload: 5cr = 135 h
Lectures 25 h
Exercises 25 h
Seminar work 30 h
Other independent studying and preparation for exam 52 h
Exam 3 h

Learning Outcomes: After the course the student
1. Can acquire the basic knowledge of safety issues in chemical process industry
2. Can identify the hazard of chemicals and chemical processes
3. Can identify the risk of damages and accidents in chemical process industry and method of prevention
4. Can apply the hazard and safety analysis methods
5. Can identify fires and explosions, and design the prevention
6. Understands the methods and techniques in chemical process safety
7. Understand the basic sustainability concepts
8. Knows the basis of the different measures to assess sustainability
9. Is able to conduct a LCA and critically interpret the results from sustainability assessment tools
10. Can apply the principles of an environmental impact assessment process

Content: 1. Introduction of process safety
2. Toxicology and industrial hygiene
3. Fires and explosions
4. Reliefs and relief equipment sizing
5. Hazards identification methods
6. Active and passive safety
7. Inherent safety
8. Development of safety management and culture
9. Safety in maintenance and electrical equipment
10. Introduction to circular economy
11. Reach
12. Sustainability principles and strategies
13. Sustainability vs. eco-efficiency
14. Sustainability assessment tools

Assessment Methods and Criteria: Lectures, Exercises, Seminar, Exam

Study Material: Lecture note, books

Grading Scale: Fail, 1 - 5

Registration for Courses: WebOodi

Language of instruction and studies: English

CHEM-E7180 Design project in chemical engineering, part B (5 cr)

Responsible teacher: Pekka Oinas
Level of the Course: Master studies
Teaching Period: I-II
Workload: Lectures 4 h
Exercises 4 h
Project work 128 h
Total: 135 h

Learning Outcomes: After the course part A the student
1. can PI-diagrams, lay out and define utilities, emissions and waste of the plant
2. can define equipment specification and instructions
3. can apply out safety (HAZOP) analysis of the process
4. can calculate capital investment, operating cost, production cost, analyze profitability and financial planning and business model
5. can demonstrate team work, presentation, management and leadership skills in real plant design

Assessment Methods and Criteria: Project-based learning, lectures and exercises, seminar presentations, group team work, meetings, and excursions

Study Material: Oinas and Golam, Design project guide

Substitutes for Courses: CHEM-E7200 (partly)

Prerequisites: CHEM-E7170 Design project in chemical engineering, Part A

Grading Scale: Fail, 1 - 5

Registration for Courses: WebOodi

Language of instruction and studies: English

Further Information: The design project course Part B is divided into three reports:
1. PI diagram, equipment specifications, instructions, layout, laws, regulation and permits, methods of safety analysis (HAZOP), heat integration
2. Cost estimations, capital cost, operating cost, profitability, time schedule, financing plan and business model
3. Final report for investment decision

CHEM-E7185 Plant/process design and business management (5 cr)

Responsible teacher: Pekka Oinas
Level of the Course: Master studies
Teaching Period: III-V
Workload: 5 cr = 135 h
Lectures and exercises, 20-24 h
Learning Outcomes: After the course the student
1. Compose a detailed design for a plant or part of a plant for the next stage (investment proposal)
2. Assess the techno-economic feasibility of the selected industrial operation
3. Describe the full chain from R&D to plant start-up
4. Analyze the business, competition and markets with different methods
5. Apply business analysis methods (Five forces, PESTEL, business model canvas)
6. Assess, calculate and analyze the financial outcomes of businesses
7. Present a business model for the selected process
8. Describe long-range plan for business development
9. Possess 'out-of-the-box' -mindset for design of industrial operations
10. Carry out successful negotiations

Content: The course format comprises of the following elements: lectures, 1 learning diary (15 %), group reports (60 %), business case demonstration (20 %) and individual activity (5 %).
1. Introduction
2. Basics of plant/process design
3. Engineering diagrams (ChemStation, MS Visio) and equipment
4. Cost assessment
5. Strategic management (external lecturer(s))
6. Marketing and sales, financial planning (external lecturer(s))
7. Business development
8. Exercises (Process computations with Aspen Plus simulation program, Business simulation, Business feasibility workshop)
9. Group work. The group work consists of 3 reports: Report 1: State-of-the-art study of selected process, process alternatives, market and competitor analysis, capacity selection
Report 2: Mass and energy balances, PFD’s, plant layout and location. Investment estimate and prefeasibility analysis
Report 3: Business simulation results, proposal to investors and stakeholders. Presentation of business model that captures the commercial value of the project.
10. Business case seminar
11. Learning diary

Assessment Methods and Criteria: Lectures, exercises, group work, seminars, business simulation
The course is very interactive comprising teaching from our school and business school. Students are expected to participate actively by:
- Assembling into effective groups with a specific design topic
- Writing learning diaries based on learnings and problems encountered
- Conducting business cases of selected processes
- Preparing thorough business analysis of selected group topics
- Using business simulation (or game) as a tool with other groups
- Having multidiscipline discussions

There will also be more traditional lecturing, also by invited guest lecturers from the School of Business School and possibly from industry.

Study Material: Lecture notes, project guide, articles

Grading Scale: Fail, 1 - 5
Registration for Courses: WebOodi

Language of instruction and studies: English

CHEM-E7195 Automation systems in Context of Process Systems Engineering (5 cr)

Responsible teacher: Sirkka-Liisa Jämsä-Jounela
Level of the Course: Master studies
Teaching Period: III-IV
Workload:
5 cr = 135 h
Lectures 20 h
Project work 111 h
Exam 4 h

Learning Outcomes:
After completing the course, the student

-Understands the structure and requirements for current plant-wide automation systems;
-Is able to configure a small DCS system for lab unit processes using ABB 800xA system and information systems environment;
-Knows the basics in process automation programming languages;
-Understands the benefits, limitations and properties of industrial field buses and can apply this knowledge in the automation system design;
-Understands the meaning of process system interfaces (OPC UA, ODBC).

Content:
Operation of current plant-wide distributed control system (DCS) and information systems, PLC programming languages (IEC 61131-3), structure and operation of Profibus, Foundation Fieldbus and Profinet field buses. Design of user interfaces (HMI): events, alarms and trends. History data collection from processes, reporting, software interfaces in process automation (OPC UA, ODBC) and future development of field buses (Ethernet, WLAN, 5G). Basics in PLC programming and C# programming, configuration and deployment of traditional I/O, field buses, and information systems. Wireless measurements, Cyber physical systems, Cloud Computing environments, 5G and their roles in the future process automation and information systems

Assessment Methods and Criteria: Lectures, project work and exam. Exam 50 % of the grade, project work 50 %.

Study Material: Compendium Lecture notes

Substitutes for Courses: CHEM-E7205 Process Automation and Information Systems: Applications

Course Homepage: MyCourses

Grading Scale: Fail, 1 - 5
Registration for Courses: WebOodi

Language of instruction and studies: English

CHEM-E8100 Organic Structural Analysis (5 cr)

Responsible teacher: Jari Koivisto
Level of the Course: Master studies
Teaching Period: I
Mechanisms in biosynthesis help us to exploit enzymatic catalysts in organic synthesis. This course will provide a brief introduction into the activation modes of enzymes and discuss opportunities and limitations for synthetic chemistry. Furthermore, the course aims to directly connect features of natural catalysts with the rational development of small molecule analogues as found in modern organocatalysis.

**Assessment Methods and Criteria:** Lectures, problem sessions, learning diary; seminar presentation

**Study Material:** All material is provided during the course. Additional information can be found e.g. in Faber: Biotransformations in Organic Chemistry, Springer; Berkessel, Gröger, Asymmetric Organocatalysis, Wiley-VCH

**Course Homepage:**

**Grading Scale:** Fail, 1 – 5

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

**CHEM-E8110 Laboratory Course in Biosystems and Biomaterials Engineering (5 cr)**

**Responsible teacher:** Alexander Frey

**Level of the Course:** Master studies

**Teaching Period:** I and II

**Workload:** Total 135 h = 5 cr Lectures and seminars 18h

Laboratory work 70h

Reporting (written and oral) 24h

Assignments 23h

**Learning Outcomes:** After the course the students will be able to plan and conduct basic experimental work by themselves

**Content:** This course provides the theoretical background and basic practical skills required for working in organic chemistry and bioscience laboratory. Use of aseptic technique in the laboratory, culturing pro- and eukaryotic cells

- working with DNA (PCR, molecular cloning, expression)
- working with proteins (protein purification, ELISA, SDS-PAGE,
- use of computational tools for analyzing of DNA molecules and in silico cloning
- synthesis of DNA molecules and in silico cloning
- spectroscopic and chromatographic characterization of compounds and evaluation of their purities

**Assessment Methods and Criteria:**
Experimentation, planning, practical implementation, reporting, assignments

**Study Material:** Materials distributed during the course

**Course Homepage:**

**Prerequisites:** Laboratory safety course CHEM-A1010 or CHEM-E0140 (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018) must have been passed.

**Grading Scale:** Fail, 1 – 5. Grading is based on active participation and completion of the experimental work (30%), reporting of results (50%) and assignments (20%).

**Registration for Courses:** WebOodi. A maximum number of 20 students can be admitted to the course. Priority is given to the degree students in Biosystems and Biomaterials Engineering major. If
there is space, other students (Aalto degree students and exchange students) with sufficient background in chemistry and biology can be admitted to the course. After the registration period the teacher of the course will inform registered students if they are accepted into the course.

**Language of instruction and studies:** English

**Further Information:**
The course starts in the second half of period I.

**CHEM-E8115 Cell Factory (5 cr)**
**Responsible teacher:** Alexander Frey
**Level of the Course:** Master studies
**Teaching Period:** III
**Workload:** Total 135 h
Lectures and Seminars 24h
Project work 40h
Self-study 67h
Exam 4h

- **Learning Outcomes:** After the course the students should be able to:
  - know the advantages and disadvantages of the different types of expression hosts
  - choose the optimal expression host for a given product
  - identify rate-limiting steps and know how to overcome them
  - modify the expression system for improved production and/or improved characteristics of the target molecule
  - select appropriate tools and strategies for genetic engineering

**Content:** This course focuses on the exploitation of cellular systems for the production of enzymes, therapeutic proteins, biochemicals and secondary metabolites. It is located at the interface between biochemistry, microbiology, cell biology and metabolic engineering. The course aims at the analysis, understanding and recombining of natures’ molecular building blocks using genetic engineering and molecular breeding technologies. This allows the creation of new expression and production systems, ranging from microbial, plant, insect to animal cells.

A project work accompanies the lectures where students design a cell factory.

**Assessment Methods and Criteria:** lectures, project work, reporting and self-study

**Study Material:** Materials distributed during the course

**Course Homepage:** https://mycourses.aalto.fi/course/search.php?search=CHEM-E8115

**Prerequisites:** CHEM-E8120

**Grading Scale:** Fail, 1 – 5; grading is based on examination (70%) and project work (30%)

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

**CHEM-E8120 Cell Biology (5 cr)**
**Responsible teacher:** Alexander Frey
**Level of the Course:** Master studies
**Teaching Period:** II
**Workload:** Total 135 h
Lectures 24 h
Assignments 27 h
Self-study 80 h
Exam 4 h

- **Learning Outcomes:** After the course the students should be able to:
  - know the advantages and disadvantages of the different types of expression hosts
  - choose the optimal expression host for a given product
  - identify rate-limiting steps and know how to overcome them
  - modify the expression system for improved production and/or improved characteristics of the target molecule
  - select appropriate tools and strategies for genetic engineering

**Content:** This course focuses on the exploitation of cellular systems for the production of enzymes, therapeutic proteins, biochemicals and secondary metabolites. It is located at the interface between biochemistry, microbiology, cell biology and metabolic engineering. The course aims at the analysis, understanding and recombining of natures’ molecular building blocks using genetic engineering and molecular breeding technologies. This allows the creation of new expression and production systems, ranging from microbial, plant, insect to animal cells.

A project work accompanies the lectures where students design a cell factory.

**Assessment Methods and Criteria:** lectures, project work, reporting and self-study

**Study Material:** Materials distributed during the course

**Course Homepage:** https://mycourses.aalto.fi/course/search.php?search=CHEM-E8115

**Prerequisites:** CHEM-E8120

**Grading Scale:** Fail, 1 – 5; grading is based on examination (70%) and project work (30%)

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

**Further Information:**
Upon request, the course can be completed also as a self-study course during summer (June & July). Deadline for completion is July 31 of each calendar year.

**CHEM-E8125 Synthetic biology (5 cr)**
**Responsible teacher:** Merja Penttilä
**Level of the Course:** Master studies
**Teaching Period:** IV-V
**Workload:** Total 135 h = 5cr
Lectures 24 h
Assignments 24 h
Other independent studying 83 h
Exam 4 h

**Learning Outcomes:** The student is able to:
1. describe the motivation for synthetic biology as a development in the technical use of biology
2. demonstrate aspects of biotechnology that currently pose limitations for its industrial use and to analyze how synthetic biology can be applied as a solution.
3. apply the concepts of synthetic biology for the design of biological systems.
4. list current research questions in the field.

**Content:** Terminology and concepts of synthetic biology. Examples of applications of synthetic

Assessment Methods and Criteria: Lectures and assignments. Group work and student presentations. Exam.

Study Material: To be announced later

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E8125

Grading Scale: Fail, 1 – 5 grading is based on assignments and exam

Registration for Courses: WebOodi

Language of instruction and studies: English

CHEM-E8130 Medicinal Chemistry (5 cr)

Responsible teacher: Jan Deska

Level of the Course: Master Studies

Teaching Period: II

Workload:
5 cr = 135 h
Lectures 24 h
Home problem solving 21 h
Independent homework 87 h
Exam 3 h

Learning Outcomes:
After the course the student will have deeper understanding on
1. how pharmaceuticals are discovered and optimized
2. how drugs exhibit desired and undesired effects
3. how biologically active molecules become pharmaceuticals

Content: The course provides a comprehensive overview of the developments in pharmaceutical research from historically relevant examples to modern medicinal chemistry and ‘biologicals’. The lectures will include in-depth discussions of important aspects such as modes of drug-target interactions, transport & metabolism, structure-activity relationship, and lead optimization & rational design. The course is complemented with general considerations regarding the development of pharmaceuticals and drug-to-market processes.

Assessment Methods and Criteria: Lectures, problem sessions and exam


Substitutes for Courses: KE-4.5120 Medicinal Chemistry (3 cr)

Grading Scale: Fail, 1 – 5

Registration for Courses: Registration via WebOodi. Please see WebOodi for registration dates.

Language of instruction and studies: English

CHEM-E8135 Microfluidics and BioMEMS (5 cr)

Responsible teacher: Sami Franssila

Status of the Course: Elective course

Level of the Course: Masters and doctoral

Teaching Period: III-IV

Workload:
Lectures: 14 h
Exercises and seminars: 14 h
Homework for exercises and seminars: 83 h
Preparation for exam: 20 h
Exam 4 h

Learning Outcomes:
The student can analyze fluid flow in microchannels and knows the relative importance of surface forces in the microscale. The student understands laminar flow and diffusion and knows the operating principles of basic microfluidic components (channels, mixers, reactors, nozzles). The student is familiar with applications of microfluidics in the fields of analytical chemistry and cell biology. The student can explain benefits of miniaturized chemical separation and detection systems. Student can describe cell behaviour on various chips and is familiar with the lab-on-a-chip and the organ-on-a-chip concepts.

Content: Fluid physics, surface science, polymer microfabrication, chemical microsystems, cell microsystems.

Assessment Methods and Criteria: Lectures, individual homework exercises, seminar talks, group work. Exercises 30 points, personal project 30 points, group project 30 points, exam 30 points (grading based on 100 points, so there is bonus possibility).

The student must get at least 50% from exam.

Study Material: Articles from scientific literature will be handed out.

Substitutes for Courses: MT-0.6081 Microfluidics and BioMEMS S-129.3001 Microfluidics and BioMEMS

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E8135

Prerequisites: Useful previous studies: basic chemistry courses, Virtaukset ja reaktorit (Fluids and reactors), Pintakemia (Surface Chemistry)

Grading Scale: 0-5

Registration for Courses: Registration via WebOodi. Please see WebOodi for registration dates.

Language of instruction and studies: English
**Doctoral level courses**

**CHEM-L1000 Toolkit for Doctoral Studies (5 cr)**

**Responsible teacher:** Markus Linder  
**Level of the Course:** Doctoral studies  
**Teaching Period:** I-V  
**Workload:**  
- Lectures 10 x 2 hour (20 hours)  
- Individual work (related to lectures) 20 hours  
- Seminars 2 x 16 hours (32 hours)  
- Small group work 63 h (42 h in part 2, 20 h in part 3)  
**Learning Outcomes:** The course consists of three themes. Firstly the students will be introduced to aims and general goals of doctoral studies. Lectures will also include practical aspects such as writing papers as well as general topics on research, patenting, and experimental design. In a second part, presentation skills will be developed. Students will work in both small groups and present before larger audiences. In the third part subjects such as researcher ethics, intellectual property rights, and research methods will be treated.  
**Content:** Introduction to doctoral studies and to professional research work, including the knowledge and the various skills needed at scientific research work, such as writing and presentation skills.  
**Assessment Methods and Criteria:** Each student must produce and present two presentations. No exam. Student must attend at least 75% of lectures.  
**Study Material:** Lecture material  
**Course Homepage:** [https://mycourses.aalto.fi/course/search.php?search=CHEM-L1000](https://mycourses.aalto.fi/course/search.php?search=CHEM-L1000)  
**Prerequisites:** M.Sc. (Tech.) degree or equivalent level degree  
**Grading Scale:** pass/fail  
**Registration for Courses:** WebOodi  
**Language of instruction and studies:** English

**CHEM-L2000 Ultrathin Films (8 cr)**

**Responsible teacher:** Eero Kontturi  
**Level of the Course:** Doctoral Studies  
**Teaching Period:** IV-V, Lectured even years  
**Workload:** 8 cr, about 213 hours  
**Learning Outcomes:** The student will be able to distinguish the main preparation techniques for ultrathin films, describe their principles, and select the relevant method. The student will also be able to master the most common surface analytical methods, their principles, and their strength and weaknesses. The student will also get a good grasp on the state-of-the-art literature on thin films, tailored towards his/her research topic.  
**Content:** Thin film preparation: spin coating, Langmuir-Blodgett deposition, drop casing, layer-by-layer deposition, electrophoretic deposition. Thin film analysis: atomic force microscopy, x-ray photoelectron spectroscopy, ellipsometry, x-ray reflectivity, electron microscopies, quartz crystal microbalance, surface plasmon resonance.  
**Assessment Methods and Criteria:** Lectures, literature review and seminar  
**Study Material:** Scientific publications appointed by the lecturer individually for each student. Lecture notes.  
**Substitutes for Courses:** -  
**Prerequisites:** M.Sc. (Tech.) degree or equivalent level degree  
**Grading Scale:** Fail, 1 – 5  
**Registration for Courses:** WebOodi  
**Language of instruction and studies:** English  
**Further Information:** -

**CHEM-L2030 Unit Operations of Paper and Board Finishing and Converting (7 cr)**

**Responsible teacher:** Jouni Paltakari  
**Level of the Course:** Doctoral studies  
**Teaching Period:** V, spring, period (even years)  
**Workload:** 7 cr = 189 h  
**Learning Outcomes:** The purpose of the course is to introduce the student to the various unit operations in finishing and converting of paper and board products.  
**Content:** The course includes the descriptions of the treatment and converting processes and their influence on the end product properties and functionality. A variety of most common products are studied with particular attention to their properties and end-use. Course includes a product analysis rehearsal work and a presentation based on this.  
**Substitutes for Courses:** Puu-21.6040  
**Grading Scale:** Fail, 1 – 5  
**Registration for Courses:** Registration via WebOodi. Please see WebOodi for registration dates.  
**Language of instruction and studies:** English

**CHEM-L2110 Advanced Molecular Modelling (3 cr)**

**Responsible teacher:** Maria Sammalkorpi  
**Level of the Course:** Doctoral studies  
**Teaching Period:** I, II, III, IV and V  
**Workload:** - contact teaching 4 h  
- independent study and project work 73 h  
- exam 4 h  
**Learning Outcomes:** After the course the student masters some advanced molecular modeling methodology and has basic hands on experience on implementing the methods and models.  
**Content:** Modeling molecular interactions, force fields, molecular dynamics, and numerics in molecular dynamics and Monte Carlo simulations through project works.  
**Assessment Methods and Criteria:** Project works and a final exam.  
**Study Material:** As agreed.  
**Substitutes for Courses:** KE-31.5550  
**Grading Scale:** Fail, 1 – 5  
**Registration for Courses:** To request this course, contact the responsible teacher.  
**Language of instruction and studies:** English

**CHEM-L2120 Research Seminar in Industrial**
Chemistry V(V) (3-7 cr)

**Responsible teacher:** Reetta Karinen
**Level of the Course:** Doctoral studies
**Teaching Period:** Intensive course
**Workload:**
- Lectures 10 h
- Seminar 10 h
- Independent studies depending on credits

**Learning Outcomes:** The aim of the course is to deepen the student's knowledge in selected field of industrial chemistry

**Content:** A seminar course where the annually changing topics cover some recent interesting subjects in the field of industrial chemistry.

**Assessment Methods and Criteria:** Seminar presentation, exam

**Substitutes for Courses:** KE-40.6500

**Grading Scale:** Fail, 1 – 5

**Language of instruction and studies:** English

**CHEM-L2140 Research Seminar on Organic Chemistry (12 cr)**

**Responsible teacher:** Ari Koskinen
**Evaluation:** hyv · Courses

**CHEM-L2210 Advanced Microfabrication V(V) (8 cr)**

**Responsible teacher:** Sami Franssila

**Status of the Course:** Doctoral CHEM, ELEC, SCI, also for masters students

**Level of the Course:** Doctoral / Master studies

**Teaching Period:** I-II, lectured odd years

**Workload:**
8 cr = 213 h
Lectures 20 h

Group project study time 80 h
Individual study time 89 h
Seminar talks (individual and group) 20 h
Exam 4 h

**Learning Outcomes:** The students can design and analyze advanced microstructures and devices.

**Content:** Microfabrication, nanofabrication, silicon wafers, lithography, etching, deposition, doping, bonding and variable content.

**Assessment Methods and Criteria:** Lectures, seminar talks, projects.

**Study Material:** Handouts, scientific articles.

**Substitutes for Courses:** CHEM-L2210 Advanced Microtechnology P V 8 op

**Prerequisites:** Microfabrication CHEM-E5115 strongly recommended

**Grading Scale:** Fail, 1 – 5

**Registration for Courses:** WebOodi

**Language of instruction and studies:** English

Further Information:
Lectured alternate years with CHEM-L2210 Thin Film Technology (8 cr) 2017
Advanced microfabrication; 2018 Thin film technology doctoral course

**CHEM-L2210 Advanced Thin Film Technology (8 cr)**

**Responsible teacher:** Jari Koskinen; Sami Franssila

**Status of the Course:** Doctoral CHEM, ELEC, SCI, also for masters students

**Level of the Course:** Doctoral / Master studies

**Teaching Period:** I-II, lectured even years, next time 2018

**Workload:** 8 cr = 213 h
Lectures 20 h
Seminars 10 h
Preparation for seminar talks 69 h
Project(s) 90 h
Exam 20 h + 4 h

**Learning Outcomes:** The students master selection and characterization of thin film processes for various applications in micro- and nanotechnologies, tribology, optics and energy technologies
Content: Thin film deposition technologies, structural and compositional analysis of thin films, applications of thin films.

Assessment Methods and Criteria: Lectures, seminar talks, group projects.

Study Material: Handouts, scientific articles.

Substitutes for Courses: MT-0.7076 Thin Film Technology Doctoral Course P 8 op

Prerequisites: Thin film technology CHEM-E5125 or Microfabrication CHEM-E5115 strongly recommended

Grading Scale: Fail, 1 – 5

Registration for Courses: WebOodi

Language of instruction and studies: English

Further Information:
Lectured alternate years with CHEM-L2200
Advanced Microfabrication V (8 cr)
Thin films next time 2018

CHEM-L2220 Research Seminar in Sustainable Metals Processing V(V) (3-5 cr)

Level of the Course: Doctoral studies
Teaching Period: I, II, III, IV, V
Workload: 81 – 135 h

Learning Outcomes: Announced yearly
Content: Experts from universities and industry give lectures concerning current issues in functional materials.
Assessment Methods and Criteria: Active participation (min 80%) in lectures (3 cr). Seminar report (5cr).
Study Material: Material delivered in lectures.
Grading Scale: 1-5 or Pass/Fail
Registration for Courses: Registration via WebOodi. Please see WebOodi for registration dates.
Language of instruction and studies: English

CHEM-L5000 Societal Models and Regulations for Sustainable Energy Services (5 cr)

Level of the Course: Doctoral studies
Teaching Period: IV-V
Learning Outcomes: A doctoral candidate knows energy systems in selected European countries reflecting participating home universities and existing and emerging sustainable energy systems in particular. He/she understands the role of support mechanisms, changing rules and policy and policy tools perspective on different mechanisms to support implementation of renewables. A doctoral candidate understands the role of different partners such as society and the consumer, national and EU level regulators, companies and academia as regards a sustainable energy system. A doctoral candidate learns essential skills such as international teamwork and multidisciplinary collaboration.
Content:
1. Introduction via two start-up lectures over Internet: An institutional perspective on the transition to a sustainable energy system: changing rules and the role of support mechanisms (TU/e)
   A policy and policy tools perspective on the different mechanisms (subsidy, feed-tariff, net-metering, certificates) to support the implementation of renewables (in Europe) (Aalto)
   0,1 cr
2. Pre-work
   Individual Assignment 1 (report):
   What is the best way to support the implementation of renewables in the EU and in member states of the EU by assessing (the impact) the support mechanisms for renewables in the country of the home university?
   Action: Delivery of the reports to all the participants Assignment 2 (an additional chapter to the previous report): comparison of the support mechanisms of the country of the home university to the mechanisms of other countries
   2 cr
3. Lectures via the Internet by academia (technologists and social scientists), company representatives and regulators (national and EU level) + corresp.reading material
   1 cr
4. Result (Assignment 3):
   A country specific essay on societal models and regulation for sustainable energy systems in Europe representing the country of the home university followed by a seminar with PowerPoint presentation on results (Eindhoven or Aalto University, TBD)
   1,8 cr
5. A publication: a collection of essays
   0,1 cr

Course Homepage:

Prerequisites: M.Sc. (Tech.) degree or equivalent level degree

Evaluation: 1-5 - Courses

Registration for Courses: WebOodi

Language of instruction and studies: English

Further Information: The course is targeted to doctorals studsens, primarily to the students in the SELECT+ Programme. The maximum number of participants in the course is 25 students. Applications needed.