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.

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.
- Link to each course’s WebOodi is embedded in the course title
- 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>
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<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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Bachelor’s level courses

★ CHEM-A1610 Design Meets Biomaterials (3-5 cr)
Responsible teacher: Tapani Vuorinen
Level of the Course: Bachelor studies
Teaching Period: IV-V
Workload: 78 h in total
  - Lectures 20 h
  - Teamwork 58 h
Learning Outcomes: After the course, students 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: Announced during the course.
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-A1610
Grading Scale: Fail, 1--5
Registration for Courses: WebOodi

Language of Instruction: English
Further Information: Course is one of the Aalto-courses. The number of students for this course is limited. Please see WebOodi for more information.

CHEM-C2120 Industrial Processes in Bio and Chemical Technology (5 cr)
Responsible teacher: Pekka Oinas
Level of the Course: Bachelor studies
Teaching Period: IV-V
Workload: 135 h in total
  - Lectures 24 h
  - Exercises 24 h
  - Project work 67 h
  - Other independent studying 20 h
Learning Outcomes: After the course the student:
  - Knows how to design economically feasible industrial processes for biotechnology and chemical technology
  - Is familiar with the essential phenomena affecting the processes in bio and chemical technology, and is also familiar with the models describing the rates of these phenomena
  - Is familiar with the unique features of natural resources’ processing
  - Is familiar with the concept of “biorefinery” and is able to choose different process routes for manufacturing the desired products
Content: Processes and products of bio and chemical technology; Biorefineries; Designing unit operations; Processing of renewable raw materials; Designing process concepts and composing flow charts; Industrial economy and profitability.
Assessment Methods and Criteria: Lectures, exercises, project work, exam.
Study Material: Announced during the course.
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-C2120
Grading Scale: 0 - 5
Registration for Courses: WebOodi
Language of Instruction: English
Further Information: Bachelor-level students majoring in Bio and Chemical Technology are able to integrate a three-credit English course with this course. The English course fulfills the university regulation on foreign language studies for oral and written skills. For the English course, participants are required to attend 80% of the contact sessions. For more information, see description of course LC-1117.
**CHEM-C2420 Materials Performance (5 cr)**

**Responsible teacher:** Eero Hiltunen  
**Level of the Course:** Bachelor level  
**Teaching Period:** IV-V  
**Workload:** 135 h in total  
- Lectures, 18-26 h  
- Assignments  
- Guiding 12-22 h  
- Independent study 60-78 h  
- Studies for the exam 24 h  
- Exam 3 h  

**Learning Outcomes:**  
After the course, student  
- Is able to describe the material response caused by mechanical loading  
- Is able to describe the behavior of a material using the theory of plasticity and mechanics of failure  
- Is able to describe the interaction between the material and chemical environment  
- Can recognize the effect of temperature on the behavior of materials  
- Can recognize the essential material characterization methods  

**Content:** Mechanical loading. Plastic deformation. Mechanics of failure. Viscoelasticity.


**Assessment Methods and Criteria:** Lectures, assignments, and exam.

**Study Material:** James F. Shackelford, Introduction to Materials Science for Engineers, 8/e, Global Edition. ISBN 978-0-273-79340-3. Other material will be announced during the course.

**Course Homepage:** [https://mycourses.aalto.fi/course/search.php?search=CHEM-C2420](https://mycourses.aalto.fi/course/search.php?search=CHEM-C2420)

**Prerequisites:** CHEM-C2400. 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:** English

**Further Information:** Bachelor-level students majoring in Material Science and Technology are able to integrate a three-credit English course with this course. The English course fulfills the University regulations on foreign language studies for oral and written skills. For the English course, participants are required to attend 80% of the contact sessions. For more information, see description of course LC-1117.
Courses of the Master's programme of Chemical, Biochemical and Materials Engineering

**CHEM-E0110 Planning and Execution of Biorefinery Investment Project (5 cr)**

**Responsible teacher:** Kyösti Ruuttunen  
**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 (autumn 2018)  
**Workload:** 135 h in total  
- 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 real-life 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.  


**Course homepage:** [https://mycourses.aalto.fi/course/search.php?search=CHEM-E0110](https://mycourses.aalto.fi/course/search.php?search=CHEM-E0110)  

**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.  

**Prerequisites:** Basic knowledge of process industry in the pulp and paper/forest biorefineries area, and a B.Sc. degree.  

**Grading Scale:** 0-5  

**Registration for Courses:** WebOodi  

**Language of Instruction:** 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:** 81 h - 135 h in total  
- 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 behavior 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 mechanical behavior of wood under static and cyclical loading and appreciates how environmental factors affect this
- Appreciates how wood might be utilized 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 structure 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 behavior, wood products, and wood product manufacturing.

Course homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E0120

Substitutes for Courses: Puu-28.5000
Introduction to wood properties and wood products

Grading Scale: 0-5

Registration for Courses: WebOodi

Language of Instruction: 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

Workload:
11 h in total
- Home exercises (in digital learning environment) or lectures 6 h
- Independent Study (studying the course material and doing the exercises) 3 h
- Exam 2 h

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. In addition, 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 be 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.

Note! Students outside CHEM/arriving to CHEM after September: If you need this course, contact the teacher in charge (currently Kirsi Yliniemi) MyCourses page. After PERIOD I, oral group exams are held an ad-hoc basis.

After the digital course is ready:
Period I-V: you can attend the digital course

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
anytime: study material and compulsory exercises can be found in 360-degree digital lab environment. The MyCourses page has a link for this digital lab environment.

**Study Material:** CHEM School's Occupational Guidelines. All material is provided either in the course's MyCourses page or in 360-degree digital lab environment.

**Course homepage:** [https://mycourses.aalto.fi/course/search.php?search=CHEM-E0140](https://mycourses.aalto.fi/course/search.php?search=CHEM-E0140)

**Substitutes for Courses:** CHEM-A1010 Turvallinen työskentely laboratoriossa (or alternatively, laboratory safety as part of courses CHEM-A1000 or CHEM-E0100 taught before Academic Year 2017-2018)

**Grading Scale:** Pass/fail

**Registration for Courses:** WebOodi.

**Language of Instruction:** English

**Further Information:** The course is undergoing digitalization, which is planned to be ready by autumn 2018.

**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 in total

**Learning Outcomes:**

- Familiarized her/himself with the services offered by the School of Chemical Engineering and Aalto University
- Mastered the basic safety guidelines regarding working in a laboratory
- 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.

**Course homepage:** [https://mycourses.aalto.fi/course/search.php?search=CHEM-E0150](https://mycourses.aalto.fi/course/search.php?search=CHEM-E0150)

**Grading Scale:** Pass/fail

**Registration for Courses:** WebOodi.

**Language of Instruction:** 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

**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:** 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, and 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:** English

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

**Responsible teacher:** Pekka Oinas

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

**Teaching Period:** III-V

**Workload:** 135 h in total
- Lectures 28 h
- Seminar/homework 50 h
- Independent work 53 h
- Exam 4 h

**Learning Outcomes:** After the course, the students are able to:
- Model chemistry and thermodynamics related to thermochemical conversion and multiphase chemical equilibrium and mass transfer.
- Prepare market study of different biomass raw material, products, material margin and process alternatives.
- Utilize engineering tools to generate material and energy balances, sustainability analysis
- Create engineering design data for equipment sizing
- Estimate capital investment, operating and production costs
- Perform profitability analysis.
- Prepare a 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, Biniari, 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:** English
characterized and used
- Define the challenges related to catalytic reactions
- Identify different stages in catalytic reactions (mass transfer and surface reactions)
- Understand how catalysts deactivate
- Are familiar with applications of catalysis


Assessment Methods and Criteria: Lectures, assignments, seminar and exam. Evaluation based on seminar and exam.

Study Material: To be announced later

Substitutes for Courses: KE-40.4150 Catalysis

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E1130

Grading Scale: 0-5

Registration for Courses: WebOodi

Language of Instruction: English

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: 135 h in total
- Lectures 22 h
- Scientific review article 55 h
- Exercises 35 h
- Self-study 23 h

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 are 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.
- Apply ethical practices and behavior in all aspects of biotechnological and chemical scientific endeavors.

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, Textbooks: 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: English

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

Responsible teacher: Herbert Sixta
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 30 h
- Project work 45 h
- Review articles on selected scientific topics from the literature 60 h

Learning Outcomes: After the course the student:
- Understands the chemistry and technology of existing and novel fractionation processes and based in this knowledge can describe the principles of a forest biorefinery
- Is 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.
- Understands the principles of the degradation and depolymerization reactions kinetics.
- Can make justified predictions about chemical reactions taking place during biomass refining processes in different conditions
- Can 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: The course presents the chemistry and technology of the existing and novel biomass refining processes, starting by presenting the most important physical and chemical pretreatment methods for the biomass raw material. In selected exercises, the kinetics of delignification and carbohydrate degradation reactions will be presented and executed, including mass transfer considerations. Thereafter, the chemistry of the fractionation processes are presented, focusing on the conventional (kraft, acid sulfite) and non-conventional (carboxylic acid, organosolv, hot water) pulping processes in detail. Further, the principles of the most promising biorefinery processes are discussed and developed together with the students in a mix of presentation and literature study. The focus is led on integrated biorefinery processes as a part of pulp mills or chemical plants. The course requires a deep understanding in wood chemistry with special emphasis on cellulose and lignin chemistry. To ensure this, the students need to prepare literature studies on selected wood chemistry topics of which parts are also orally presented and discussed among the students under the guidance of the lecturer in charge. In the final phase of the course, the students need to prepare a scientific review article on a selected topic in biorefineries.

Study Material: Lecture notes, textbooks 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: 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
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
- 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
- Has practiced the most essential experimental and analytical methods in the area of biomass refining and is familiar with some less conventional practical laboratory methods.
- Based on the practical experience, can make justified predictions about chemical reactions taking place during biomass refining processes in different conditions.
- Is able to describe the principles of the advanced analytical methods for structural characterization of lignocellulosic constituents.
- Is familiar with principles of project planning and has team-working experience; has practiced giving and receiving positive and constructive feedback
- 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, Klason 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 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.

Study Material: To be announced in class.
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E1160
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: English
Further Information: Students chosen to this course are primarily major students (Biomass Refining). 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-E1200 Integration and Products (10 cr)
Responsible teacher: Olli Dahl
Level of the Course: Master’s level
Teaching Period: I-II
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: 10 h

Learning Outcomes:
After the course the student can
- Realize why we need bioproducts and recognize most significant bio-based products and their properties
- Understand market mechanism and dynamics of the products
- Understand impact of the raw material properties on final product quality
- Describe principles of process integration, e.g. understand role of side streams and wastes as a raw material for new products
- Plan, create and estimate sustainable value chains to produce value added products and estimate the sustainability of the existing biorefinery processes
- Form mass and energy balances for the processes
- Evaluate economy of the processes (capital investment, operating cost, production cost, profitability and financial planning, legal aspects)
- Evaluate environmental impacts of the processes and products (LCA calculations, emissions, efficiency, raw materials, transportation, climate chance, legal aspects)
- 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: https://mycourses.aalto.fi/course/search.php?search=CHEM-E1200

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: English

CHEM-E2100 Polymer Synthesis (5 cr)

Responsible teacher: Mauri Kostiainen

Level of the Course: Master’s level

Teaching Period: I

Workload: 135 h in total
- 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 polymerizations
- 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. Polymerization mechanisms, stepwise synthesis of branched polymers and biological synthesis of biopolymers are discussed.

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


Substitutes for Courses: KE-100.3200 Polymer Synthesis

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E2100

Grading Scale: 0-5

Registration for Courses: WebOodi

Language of Instruction: 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: 135 h in total
- 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 utilized 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 behavior 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, laboratory exercises, project work and other independent studying.

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

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E2105
Grading Scale: 0-5

Registration for Courses: WebOodi
Language of Instruction: English

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

Responsible teacher: Pirjo Pietikäinen
Level of the Course: Master’s level
Teaching Period: I-II
Workload: 135 h in total
- 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 analyze 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, and polymer processing and testing. The course consists of nine laboratory exercises and their reporting. The course ends with a seminar.
Assessment Methods and Criteria:
Lectures 2h, Exercise and reporting 128 h, and Seminar 4 h.

Substitutes for Courses: KE-100.3500, KE-100.3510

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E2110

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: English

Further Information: Students chosen to this course are primarily major students (Fibre and Polymer Engineering). If more than 26 students enroll to this course, the number of course participants can be limited. All major students are chosen to the course if enrolled in time.

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: 135 h in total
  - 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

Content: Structure, properties and applications of wood products including the relevant performance standards. Mechanical and physical (e.g. thermal) performance characteristics of wood products in service. Resource efficiency and environmental footprint of wood and wood products, including life cycle analyses and carbon storage. Long-term performance of wood and wood products, including physical and biological degradation. Enhancing performance through appropriate design, wood modification, preservation and coating.

Assessment Methods and Criteria:
Lectures 8 - 12 h, exercises 8 - 12 h, excursions and/or project work 81 - 99 h, and other independent studying 20 - 30 h.

Study Material: To be announced later

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E2115

Grading Scale: 0-5

Registration for Courses: WebOodi

Language of Instruction: English

CHEM-E2120 Fibres and Fibre Products (5 cr)

Responsible teacher: Thaddeus Maloney

Level of the Course: Master’s level

Teaching Period: I

Workload: 135 h in total
  - 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, and 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: 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: 135 h in total
- Lectures, labs and independent reading 115 h
- Exam preparation 20 h

Learning Outcomes: After the course the student
- 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, group work, and self-study for exam

Study Material: To be announced later

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.

Grading Scale: 0-5

Registration for Courses: WebOodi

Language of Instruction: English

CHEM-E2130 Polymer Properties (5 cr)

Responsible teacher: Jukka Seppälä

Level of the Course: Master’s level

Teaching Period: II

Workload: 135 h in total
- 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 the 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, and other independent studying


Substitutes for Courses: KE-100.3410

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E2130

Prerequisites: Basics of polymer structures.

Grading Scale: 0-5

Registration for Courses: WebOodi

Language of Instruction: English

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CHEM-E2135 Converting of Web-Based Products (5 cr)

Responsible teacher: Eero Hiltunen
Level of the Course: Master’s level
Teaching Period: IV-V
Workload: 135 h in total

- Lectures/workshops 35 h
- Labs/group work 60 h
- Other independent studying 20 h
- Exam preparation 20 h

Learning Outcomes: After the course the student:
- Has a deeper understanding of the value chain from reel-form materials to customer-specific end products, multi material solutions, such as packaging and their properties
- Knows the most common unit operations, finishing, converting and printing processes
- Is able to measure, analyze and characterize the properties of these converted products and packaging material
- Is able to do product analysis for a converted multi material product
- Knows various end use areas of converted material in industries
- Knows the basics of packaging technology

Content: This course continues the value chain of web-based natural fiber products with several finishing and converting operations and processes. Various unit operations in finishing and converting of paper and board products are covered. This includes the descriptions of the treatment, converting and printing processes and their influence on the end product properties and functionality. Varieties of most common products are studied with particular attention to their properties and end-use requirements. Intelligent multi material solutions and the basic concepts in packaging technology are also covered. The course includes a product analysis exercise. Course also includes laboratory exercise with converted materials and a presentation based on this.

Assessment Methods and Criteria: Lectures, laboratory work, group work, homework, and self-study for exam.

Study Material: To be announced later.

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E2135

Prerequisites: CHEM-E2125 Web-based natural fiber products 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: 0-5

Registration for Courses: WebOodi

Language of Instruction: English

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CHEM-E2140 Cellulose-Based Fibres (5 cr)

Responsible teacher: Eero Kontturi
Level of the Course: Master’s level
Teaching Period: I-II
Workload: 135 h in total
- Lectures 24 h
- Exercises 24 h
- Project work 67 h
- Self-study for exam 20 h

**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 organization 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 behavior 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, exercises, project work, and self-study for exam.

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

**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:** English

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**CHEM-E2145 Polymer Reaction Engineering (5 cr)**

**Responsible teacher:** Jukka Seppälä

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

**Teaching Period:** III-V

**Workload:** 135 h in total

- Lectures 24 h
- Home assignments 60 h
- Independent studying 20 h
- Exam and self-study 30 h

**Learning Outcomes:**
After the course the student:
- Understands how the most common polymerization mechanisms affect polymerization reactions.
- Knows the production technologies of the most common polymers and understands the special features of reactor types.
- Knows how the safety and stability of polymer reactors can be affected and is able to use stability analysis in research and development of polymer processes.
- Understands how viscosity affects polymerization processes and can design mixing and heat transfer of polymerization reactors.
- Can scale up/down mixing of polymerizations.
- Understands the use of reactor calorimeter in polymerizations 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, and exam.

**Study Material:** Odian: Principles of Polymerization, 3rd. ed. (selected parts).
Compendium.

**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:** English

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**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:** 135 h in total

- Lectures 20 - 24 h
- Exercises 4 - 8 h
- Lab work 5 - 10 h
- Self-study, home assignments, laboratory report and studying for exam 90 – 110 h

**Learning Outcomes:**

After the course, the student

- Recognizes the theoretical background of surface and colloid chemistry, and can explain the basic solution properties of colloid systems.
- Can discuss about the adsorption of polyelectrolytes and surfactants using theoretical background and apply them to the biorefinery technology.
- Can designate the use of nanotechnology in the field of renewable materials.
- Understands the bottom-up principle of designing new materials and knows the special features of working with nanoparticles in practice.

**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.

**Study Material:** The book “G.T. Barnes and I.R. Gently. Interfacial Science (Oxford University Press)”, and other material given in the course.

**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:** English

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**CHEM-E2155 Biopolymers (5 cr)**

**Responsible teacher:** Orlando Rojas Gaona

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

**Teaching Period:** III-IV

**Workload:** 135 h in total

- 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, and exam.

**Study Material:** To be set separately

**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

**CHEM-E2160 Product Development Practices (5 cr)**

**Registration for Courses:** WebOodi

**Language of Instruction:** English

**Responsible teacher:** Jouni Paltakari

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

**Teaching Period:** III-V

**Workload:** 135 h in total
- 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.
- Recognizes the chain of events that takes place between assessing an un-met consumer need and delivering a finished product.
- Realizes 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, and 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:** 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:** 81 h - 135 h in total
- Lectures 4 x 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 software
- 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
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 software: 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, and closing seminar with presentations.

Study Material: Software: UCSF Chimera, Povray, and Blender.

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E2165
Grading Scale: Pass/fail
Registration for Courses: WebOodi
Language of Instruction: 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: 135 h - 270 h (5 - 10 cr). 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

Course homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E2185
Registration for Courses: Registration via WebOodi. Please see WebOodi for registration dates.

Language of Instruction: 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: The workload depends on the number of credits: 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. To be agreed with the responsible teacher.

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: English
**CHEM-E2200 Polymer Blends and Composites (5 cr)**

**Responsible teacher:** Mark Hughes  
**Level of the Course:** Master’s studies  
**Teaching Period:** I  
**Workload:** 135 h in total  
- Lectures 14 h  
- Project work and presentation 81 h  
- Self-study for exam 40 h

**Learning Outcomes:**  
After the course the student:  
- Is 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, and 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](https://mycourses.aalto.fi/course/search.php?search=CHEM-E2200)

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

**Registration for Courses:** WebOodi

**Language of Instruction:** English

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**CHEM-E2210 Product Development - Project Course (10 cr)**

**Responsible teacher:** Jouni Paltakari  
**Level of the Course:** Master’s studies  
**Teaching Period:** I-IV  
**Workload:** 260 h in total  
- Lectures 5 - 10 h  
- Seminars 10 h  
- Project work 200 h  
- Self-study 40 - 45 h

**Learning Outcomes:**  
After the course, the students:
- Are able to manage in engineering work situation where you need to find a proper solution for a problem in a limited time.
- Can utilize core and advanced knowledge in designing a product.
- Is able to utilize 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 checkpoint meetings, learning diary
and intermediate evaluations. The final outcomes are concepts 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, and 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](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:** English

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**CHEM-E3100 Biochemistry (5 cr)**

**Responsible teacher:** Silvan Scheller

**Level of the Course:** Master studies

**Teaching Period:** I

**Workload:** 135 h in total
- Lectures 24 h
- Assignments or exercises 24 h
- Other independent studying 83 h
- Exam 4 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.
- Select methods for the determination of structure and function of enzymes, enzyme catalysis and protein modification.
- 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, exercises and a written exam. The exam is 75% of the grade and 25% of the grade is obtained by approved completion of assignments or exercises within the set deadlines.

**Study Material:** To be announced later

**Course Homepage:** [https://mycourses.aalto.fi/course/search.php?search=CHEM-E3100](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:** English

**Further Information:** Professor Silvan Scheller

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**★ CHEM-E3110 Biolab I (5 cr)**

**Responsible teacher:** Heli Viskari

**Level of the Course:** Master studies

**Teaching Period:** I

**Workload:** 135 h in total
- Laboratory and experimentation 75 h
- In addition: lectures, reporting (written and oral), and assignments and self-study

**Learning Outcomes:**
After the course the students:
- Have sound theoretical knowledge about methods used in biotechnology laboratories
- Have a good understanding of relevant regulations and safety aspects when working in biotechnology laboratories
Will be able to perform basic microbiology and biochemistry laboratory experiments
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, and 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: 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 previous knowledge in cell biology and biosciences by providing a more detailed view into systematic and applied microbiology. The

CHEM-E3120 Microbiology (5 cr)

Responsible teacher: Katrina Nordström
Level of the Course: Master studies
Teaching Period: I
Workload: 135h in total
  - 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:
  - Present the structure and physiology of pro- and eukaryotic micro-organisms
  - List the principles of cell growth and underlying intrinsic and extrinsic factors which influence microbial growth including adaptation and sensing
  - Describe human - microbe interactions, cell-cell interactions, pathogenicity and antimicrobial control measures
  - 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 focuses 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 M.Sc. level course 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-E3110 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 completed according to the required deadlines, and failure to comply with deadlines will results in forfeiting the 20% for the final grading.

Registration for Courses: WebOodi
Language of Instruction: English. Exams can be completed in English, Finnish or Swedish, but the exam questions will only be given in English.
Further Information: Dr. Katri Juuti, Ph.D. will lecture this course.

⊗ CHEM-E3130 Biolab II (5 cr)

Responsible teacher: Tero Eerikäinen
Level of the Course: Master studies
Teaching Period: I I
Workload: 135h in total
- Introductory lectures 4 h
- Laboratory and experimentation 85 h
- Planning, entry test 21 h
- Reporting (written and oral) 25 h

Learning Outcomes:
The students will be able to
- Design, carry out, analyze and report experimental procedures in wet-lab regarding biological phenomena and bioprocesses
- Interpret certain metabolic pathways and adapt methods to analyze and engineer those for novel products and for better efficiency
- Apply modern techniques of measurements, analysis, and control at different levels of examinations (molecular, single cell, population, reactor, process, plant)
- Master practical application of common equipment to produce and apply biotechnical materials and compounds (cells and enzymes and their products)
- 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

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 lab 30
- Laboratory work diary 15
- Reports 30
- Seminar presentation 10
- Final exam 15

Registration for Courses: WebOodi
Language of Instruction: 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: 135 h in total
- Lectures 14 h
- Group work 43 h
- Calculation exercise 8 h
- Learning diary 8 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 fermentation technology, batch, fed batch and continuous fermentation, 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, separation of soluble and insoluble products, design and control the bioprocess parameters

**Assessment Methods and Criteria:** Lectures, Exercises, Assignments, Group work and Examination

**Study Material:** Reference books:

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

**Course Homepage:**

**Prerequisites:** CHEM-E3100 Biochemistry, CHEM-E3120 Microbiology, CHEM-C2310 Bioprocess Technology I

**Grading Scale:** The course is graded: fail, 1 – 5.

**Registration for Courses:** WebOodi

**Language of Instruction:** English

**Further information:** Please note that course registration will be closed before a week when actual teaching starts for managerial reason. You need to contact a teacher individually for registration, once the deadline is over.

**CHEM-E3150 Biophysical chemistry L (5 cr)**

**Responsible teacher:** Markus Linder

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

**Compulsory course in Biotechnology major**

**Level of the Course:** Master studies

**Teaching Period:** III

**Workload:** Total 135h in total
- Lectures 24 h
- Assignments 24 h
- Other independent studying 83 h
- Exam 4 h

**Learning Outcomes:** After the course, the student has the ability to:

- Present the physical basis for the function of biological macromolecules.
- Describe a broad range of analytical techniques for studying biological molecules and their biophysical behavior.
- Demonstrate the thermodynamic basis for biological interactions, kinetics, and functions.
- Understand the use of thermodynamic models for predicting the outcome of biological processes.
- Apply the above knowledge to food science, medical technology, bioanalytical measurements, biomaterials processing, and bioscience research.

**Content:** Protein structure and folding, and evolution. Theoretical and practical aspects of methods for the separation and characterization of biological macromolecules. The processes of sedimentation, diffusion and aggregation. Using calorimetry and analytical techniques to study molecular interactions. A basic understanding of the methods to determine three-dimensional structures of biological macromolecules. The application of thermodynamics in biological systems. The thermodynamic basis for cellular conversion and metabolism. The thermodynamic basis for macromolecular behavior and interactions. Mathematical models to understand interactions, including cooperative effects. Principles and applications of colloid and surface science to biomaterials. The basis of enzyme catalysis.

**Assessment Methods and Criteria:** The course
consists of lectures and assignments. Individual problem solving exercises.


**Course Homepage:** https://mycourses.aalto.fi/course/search.php?search=CHEM-E3150

**Prerequisites:** CHEM-E3140 Bioprocess technology, CHEM-E3130 Biolab II, or equivalent

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

**Registration for Courses:** WebOodi

**Language of Instruction:** English

**Further Information:** markus.linder@aalto.fi

★ **CHEM-E3160 Biolab III (5 cr)**

**Responsible teacher:** Heli Viskari

**Level of the Course:** Master studies

**Teaching Period:** IV-V

**Workload:** 135h in total
- Lectures 24 h
- Computer exercises 24 h
- Assignments 30 h
- Independent studying 53 h
- Exam 4 h

**Learning Outcomes:**
After the course, the student:
- Understands the concepts of Systems biology and how they can be applied to address various research questions
- Knows how –omics technologies are applied to generate data
- Can apply computational tools to treat high-throughput data
- Can differentiate between a reductionistic and a holistic view of a cell
- Can quantitatively describe biological phenomena
- Analyze the behavior of small biological

**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.

**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:** 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 inform registered students if they are accepted into the course. Mandatory laboratory exercises take place during period IV, reporting and final presentation take place in period V.

**CHEM-E3170 Systems biology (5 cr)**

**Responsible teacher:** Alexander Frey

**Level of the Course:** Master studies

**Teaching Period:** IV-V, offered in even years

**Workload:** 135h in total
- Lectures 24 h
- Computer exercises 24 h
- Assignments 30 h
- Independent studying 53 h
- Exam 4 h

**Learning Outcomes:**
After the course, the student:
- Will be able to plan and conduct basic experimental work by themselves
- Can use methods used in molecular biology laboratories
- Can genetically modify pro- and eukaryotic expression hosts
- Know and can apply methods for screening and selection
- Can apply computational tools to treat high-throughput data
- Can differentiate between a reductionistic and a holistic view of a cell
- Can quantitatively describe biological phenomena
- Analyze the behavior of small biological
networks using modeling and simulation
- Can model basic microbial metabolism

Content: The course aims at the analysis and understanding of biological phenomena using –omics tools, mathematical models and simulations. In the course students learn to view the cell as a complex system of interacting components (DNA-protein, protein-protein or metabolite-enzyme). As the individual components often are involved in many different reactions, complex networks are evolving which govern the cellular activities. These 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: English

CHEM-E3180 Concepts in Biochemistry (5 cr)

Responsible teacher: Silvan Scheller

Level of the Course: Master studies

Teaching Period: II-III

Workload: 135 h in total
- Lectures 24 h
- Exercises or assignments and possible seminar(s) 30h
- Other independent studying 78 h
- Exam 3 h

Learning Outcomes:
- Profound understanding of selected concepts in biochemistry. Ability to utilize learned concepts to solve future challenges.
- Understand principles in enzyme catalysis.
- Knowledge about methods to study and engineer enzyme function

Content: Case studies in biochemistry with a focus on enzymes, coenzymes and metabolic pathways. The course involves the following parts: Types of enzymes, enzyme kinetics, tools to study enzyme mechanisms, concepts of enzyme engineering, learn how nature is carrying out chemistry. A short project work done in groups of two students is also part of the course; its topic may be chosen within any area of biochemistry.

Assessment Methods and Criteria: Lectures, exercises and assignments

Study Material: Materials to be announced.

Substitutes for Courses: CHEM-E3215 Advanced Biochemistry

Course Homepage: MyCourses

Prerequisites: CHEM-E3100 Biochemistry or equivalent

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

Registration for Courses: WebOodi

Language of Instruction: English

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

Responsible teacher: Tero Eerikäinen

Level of the Course: Master studies

Teaching Period: I

Workload: 135 h in total
- Lectures and exercises 24 h, 2 x 2 h per week
- Experimental work 15 h
- Assignments 12 h
- Independent studying 80 h
- Exam 4 h

Learning Outcomes:
After completing the course, students will be able to:
- Build kinetic simulation models of the cell growth and product formation
- Connect different models together to build a bioprocess model
- Define parameters for kinetic and static bioprocess models
- Create experimental designs for bioprocess screening and optimization tests
- Create response surface models and define optimum variable values thereof
- Create multivariate models from various data sources including e.g. raw materials, cultivation conditions, product properties, expression data
- Utilize certain chemometric modeling approaches for bioprocess estimation and simulation simulations
- Arrange simple experiments to find out certain kinetic and optimization parameters of a bioprocess
- Estimate the model validity in various cases

**Content:** Bioprocess behavior in different modes and modeling principles. Computer-aided bioprocess modeling and simulation. Creating bioprocess models in MATLAB and Simulink environment. Linear and non-linear estimation of the kinetic parameters for types and models. Multivariate modeling possibilities and limitations. Response surface modeling, principal component analysis, neural networks. Use of models as a part of Quality control as process analytical technique. Creating a bioprocess simulation model and validating parameter values from experimental data.

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

**Study Material:** Material to be announced

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**Course Homepage:**

**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:** English

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

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**Chem-E3225 Cell and Tissue Engineering (5 cr)**

**Responsible teacher:** Katrina Nordström

**Level of the Course:** Master studies

**Teaching Period:** III-IV

**Workload:** 135 h in total
- 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:
- Describe classes of cells with potential for use for cell-based and tissue-engineering products
- Present culturing techniques, growth requirements in vivo and in vitro, and selected bioreactors
- Discuss choices and materials for scaffolds
- 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 in 2D and 3D including bioreactors. Control of contamination, safety, efficacy and ethics.

**Assessment Methods and Criteria:** Laboratory projects in groups. Grading is based on written examination (50%), and project work (50%). Project work should be allocated approximately 5 hours per week, on average, during period III. There is a home exam based on textbook and selected online materials (to be announced in MyCourses).

**Study Material:** To be announced.

**Course Homepage:**

**Prerequisites:** CHEM-E3100 Biochemistry, CHEM-E3120 Microbiology or equivalent. The student must have completed the laboratory safety course CHEM - A 1010 or CHEM E0140 (or alternatively an equivalent course on laboratory safety) before starting work in the lab. A student who does not
have the possibility to comply with this requirement should contact the course responsible teacher before enrollment to the course.

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 or visiting students are accepted only if there is space in the order specified.

Language of Instruction: English

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

Responsible teacher: Kari Laasonen
Level of the Course: Master studies
Teaching Period: I-II

Workload: 260 h in total
- 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/pass
Registration for Courses: WebOodi
Language of Instruction: English

CHEM-E4105 Nanochemistry and Nanoengineering (5 cr)

Responsible teacher: Mady Elbahri
Level of the Course: Master studies
Teaching Period: IV

Workload: 135 h in total
- Lectures and labs 30 h
- Seminars 11 h
- Home problem solving 20 h
- Independent homework 70 h
- Exam 4 h

Learning Outcomes:
After the course the student
- Masters the basic principles of green nanotechnology, nanochemistry and nanoengineering
- Has an overview of state-of-the-art synthesis techniques of advanced nanomaterials and new-material design of the desired functions
- Is able to analyze physical property relations in functional materials
- Is able to apply methods, approaches or 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-E4105

Grading Scale: Fail, 1-5
Registration for Courses: WebOodi
Language of Instruction: English

CHEM-E4110 Quantum mechanics and Spectroscopy (5 cr)

Responsible teacher: Kari Laasonen
Level of the Course: Master studies
Teaching Period: II
Workload: 135 h in total
- Lectures 36 h
- Exercises 12 h
- Project work 24 h
- Other independent studying 60 h
- Exam 3 h

Learning Outcomes: After the course the student will know
- The basics of molecular quantum mechanics and understand the nature of chemical bonds.
- The difference of atomic and molecular orbitals.
- The principles of photon adsorption of molecules.
- The basics of rotational, vibrational and electronic spectroscopy
- Some of the rotational, vibrational and XPS databases

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

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: 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: English

**CHEM-E4115 Computational Chemistry I (5 cr)**

Responsible teacher: Kari Laasonen
Level of the Course: Master studies
Teaching Period: II
Workload: 135 in total
- Lectures 36 h
- Exercises 12 h
- Assignments 30 h
- Other independent studying 57 h

Learning Outcomes:
After the course the student will know:
- Will know the basics of computational quantum chemistry
- Will know the Hartree-Fock theory, some correlation methods and the concept of basic functions
- Can model various molecules and molecules properties with modern quantum chemistry software
- Will be familiar with empirical molecular modelling, empirical force fields, molecular dynamics and Monte Carlo methods
- 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: https://mycourses.aalto.fi/course/search.php?search=CHEM-E4115

Prerequisites: CHEM-E4110 Quantum mechanics and Spectroscopy or equivalent
Grading Scale: Fail, 1 – 5
Registration for Courses: WebOodi
Language of Instruction: English

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

Responsible teacher: Sakari Kulmala
Level of the Course: Master studies
Teaching Period: I
Workload: 135 h in total
- Lectures 30 h
- Laboratory exercises 16 h
- Independent homework 62 h
- Exam 3 h

Content: Basics of molecular modelling.
Learning Outcomes:
After the course, the student will be able to
- Describe the theoretical basis of currently important instrumental analysis methods excluding electroanalytical methods.
- Describe the functional components of the instrument/instruments used in the method.
- Select suitable methods based on the actual needs (i.e. allowed costs, precision, detection limit, calibration range).
- 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 classroom problems, and final examination.

Study Material: As agreed.

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E4120

Grading Scale: Fail, 1-5

Registration for Courses: WebOodi

Language of Instruction: English

CHEM-E4130 Chemistry of the Elements (5 cr)
Responsible teacher: Maarit Karppinen
Level of the Course: Master studies

Teaching Period: II
Workload: 135 h in total
- 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
- Explain the basic features of the transition metal chemistry.
- Derive the basic chemical and physical properties of d-block and f-block transition metals from their electron structures.
- Name the coordination compounds and describe their structures.
- Describe the most important compounds of transition elements and name their applications.
- 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, lanthanides and actinides.

Assessment Methods and Criteria: Lectures, seminar presentation, homework and classroom problems, and final examination.

Study Material: As agreed.

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E4130

Grading Scale: Fail, 1-5

Registration for Courses: WebOodi

Language of Instruction: English

CHEM-E4135 Advanced Analytical Chemistry (5 cr)
Responsible teacher: Sakari Kulmala
Level of the Course: Master studies
Teaching Period: III
Workload: 135 h in total
- Lectures 26 h
- Exercises 40 h
- Independent homework 40 h
- Exam 3 h

Learning Outcomes: After the course, the student will be able to
- Utilize and treat relatively complicated simultaneous combinations of chemical equilibria.
- Describe the current status of analytical quality systems and general analytical regulations by authorities and scientific community.
- Perform validation processes.
- Understand and manage the time scale of different patenting routes.
- 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 classroom problems.
and final examination

**Study Material:** As agreed

**Course Homepage:**

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

**Registration for Courses:** WebOodi

**Language of Instruction:** English

**CHEM-E4150 Reactivity in Organic Chemistry (5 cr)**

**Responsible teacher:** Pekka Joensuu

**Level of the Course:** Master studies

**Teaching Period:** II

**Workload:** 135 h in total
- Lectures 24 h
- Problem sessions 10 h
- Home problem solving 20 h
- Independent homework 70 h

**Learning Outcomes:**
- Student will have a deeper understanding on reaction mechanisms and reasons for reactivity. New types of reaction will be presented: Radical, pericyclic and carbenes. Student will be familiar with most common heterocycles, their properties, reactivity and synthesis. Student will be offered basic tools and methods for determining reaction mechanisms.

**Assessment Methods and Criteria:** Lectures, problem sessions, and exam

**Study Material:** Clayden, Greeves, Warren: Organic Chemistry; chapters 29-31 and 34-39.

**Course homepage:**

**Substitutes for Courses:** CHEM-E4140 Selectivity in in Synthesis and Recognition

**Prerequisites:** CHEM-C2220 Elements of organic synthesis or equivalent

**Grading Scale:** Fail, 1 – 5

**Registration for Courses:** WebOodi

**Language of Instruction:** English

**CHEM-E4155 Solid State Chemistry (5 cr)**

**Responsible teacher:** Antti Karttunen

**Level of the Course:** Master studies

**Teaching Period:** IV-V

**Workload:** 135 h in total
- Lectures, combined with exercises 32 h
- Home problem solving 48 h
- Independent project work 55 h

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

- Apply the basic concepts of structural chemistry, such as unit cell, lattice parameters, crystal system, and space group.
- Search crystal structures of inorganic solid-state compounds from databases, analyze and visualize the crystal structures.
- Analyze bonding in solid-state chemistry: Electronegativity, radii and packing of atoms, ligand field theory, band theory.
- Describe synthesis methods used in solid-state chemistry and read the information given in various phase diagrams.
- Analyze information from various structure characterization methods and utilize powder X-ray diffraction data for phase identification.
- Describe the roles of crystal defects, doping, and non-stoichiometry.
- Explain basic structure-property correlations of various inorganic materials.

**Content:** Structure, bonding, synthesis, and characterization of solid-state materials. Use of crystal structure databases, visualization of crystal structures, interpretation of phase diagrams, and phase identification with powder X-ray diffraction data. Application of the above core concepts to various main group compounds and transition metal compounds.

**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: English

CHEM-E4165 Chemical instrumentation and electroanalytical methods (5 cr)
Responsible teacher: Sakari Kulmala
Level of the Course: Master studies
Teaching Period: IV-V
Workload: 135 h in total
  - Lectures 26 h
  - Home problem solving 40 h
  - Independent homework 56 h
  - Exam 3 h
Learning Outcomes:
After the course, the student will be able to
  - Describe the theoretical basis of currently important electroanalytical methods.
  - Describe the functional components of the instrument/instruments used in the method.
  - Utilize the strengths of electroanalytical methods when they exist in comparison to other instrumental analysis methods.
  - Describe the function of electronical components used in electroanalytical instrumentation and in chemical instrumentation in general.
  - Find and read basic scientific literature on a given topic related to the novel developments of selected method/method group or novel instrumentation solutions.
Content: The course covers all the important electroanalytical methods used in quantitative analysis.
Assessment Methods and Criteria: Lectures, exercises, homework and classroom problems and final examination
Study Material: As agreed
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E4165
Grading Scale: Fail, 1-5
Registration for Courses: WebOodi
Language of Instruction: English

CHEM-E4175 Fundamental Electrochemistry (4 cr)
Responsible teacher: Tanja Kallio
Level of the Course: Master studies
Teaching Period: III
Workload: 108 h in total
  - 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.
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)
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=e4175
Grading Scale: Fail, 1 – 5
Registration for Courses: Registration via WebOodi. Please see WebOodi for registration dates.
Language of Instruction: English

CHEM-E4185 Electrochemical Kinetics (6 cr)
Responsible teacher: Lasse Murtomäki
Level of the Course: Master studies
Teaching Period: IV-V
Workload: 162 h in total
  - 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
- Understand the basics of modern electrochemistry
- Understand the theory of electrochemical experimental methods
- Interpret experimental results

**Content:** The course deals with kinetics of electrochemical reactions and modern experimental methods: potential/current step, potential scan, rotating disk, channel flow and ultramicroelectrodes.

**Assessment Methods and Criteria:** Lectures, home exercises, laboratory work, and exam

**Study Material:** Lecture notes in MyCourses
C.M.A. Brett, A.M. Oliveira-Brett, Electrochemistry: Principles, methods, and applications, Oxford University Press, 2005
Textbooks available for borrowing.

**Course homepage:**

**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:** English

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**CHEM-E4195 Selectivity in Organic Synthesis (5 cr)**

**Responsible teacher:** Jan Deska

**Level of the Course:** Master studies

**Teaching Period:** IV

**Workload:** 135 h in total
- 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, and seminar presentations

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

**Course homepage:**

**Prerequisites:** CHEM-E4150 Reactivity in Organic Synthesis or equivalent

**Grading Scale:** Fail, 1 – 5

**Registration for Courses:** WebOodi

**Language of Instruction:** English

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

**Responsible teacher:** Maarit Karppinen

**Level of the Course:** Master studies

**Teaching Period:** I

**Workload:** 135 h in total
- Lectures 24 h
- Exercises 12 h
- Seminars 10 h
- Home problem solving 20 h
- Independent homework 65 h
- Exam 4 h

**Learning Outcomes:** After the course, the student will be able to
- Use symmetry elements for the description of the symmetries of molecules and crystals
- Determine the point group for a molecule
- Read the space group symbols so as to understand the information provided by the symbol
- Draw unit cells once the lattice parameters, atomic coordinates and the
space group are known
- Explain the diffraction phenomenon
- Explain the steps in crystal structure determination and the principles of Rietveld refinement; evaluate the feasibility of a crystal structure model based on a bond valence sum (BVS) calculation
- Explain the principles of the most important structural characterization techniques, understand, and critically evaluate the information revealed by the techniques for inorganic materials.
- Select the most suitable technique(s) for each specific structure-related research problem

Content: The course deals with structural characterization techniques of inorganic materials and covers 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 classroom 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, or equivalent

Grading Scale: Fail, 1-5

Registration for Courses: WebOodi

Language of Instruction: English

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**CHEM-E4210 Molecular Thermodynamics L (5 cr)**

Responsible teacher: Maria Sammalkorpi

Level of the Course: Master / Doctoral studies

Teaching Period: II

Workload: 135 h in total
- Lectures 24 h (12 x 2 h)
- Exercises 12 h - 24 h
- Assignments 12 h – 36 h
- Other independent studying 51 - 87 h

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: https://mycourses.aalto.fi/course/search.php?search=CHEM-E4210+

Prerequisites: CHEM-C2200 Chemical Thermodynamics or equivalent

Grading Scale: Fail, 1-5

Registration for Courses: WebOodi

Language of Instruction: English

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**CHEM-E4215 Functional Inorganic Materials (5 cr)**

Responsible teacher: Maarit Karppinen

Level of the Course: Master studies

Teaching Period: II

Workload: 135 h in total
- Lectures 30 h
- Home problem solving 30 h
- Independent homework 72 h
Learning Outcomes:
After the course, the student:
- Has an overview of the variety of inorganic materials employed in advanced technologies
- Is able to discuss the most important physical properties of functional in materials
- Is able to analyze the basic chemistry - crystal structure - microstructure - physical property relations in functional materials
- Is able to read and critically evaluate scientific papers on topics related to inorganic materials chemistry

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, thermoelectric, Li-ion and oxide-ion conductive and photoactive materials, and the physical phenomena behind the targeted material functions. The focus is on new materials.

Assessment Methods and Criteria: Lectures, exercises, assignments
Study Material: Mostly material given in lectures and C.J. Cramer, Essentials of Computational Chemistry (Wiley).
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E4225
Prerequisites: CHEM-E4115 Computational Chemistry I or equivalent
Grading Scale: Fail, 1-5
Registration for Courses: WebOodi
Language of Instruction: English

CHEM-E4225 Computational Chemistry II (5 cr)
Responsible teacher: Kari Laasonen
Level of the Course: Master studies
Teaching Period: IV-V
Workload: 135 h in total
- Lectures 36 h
- Exercises 12 h
- Assignments 30 h
- Other independent studying 57 h

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


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: 135 h in total
- Lectures 24 h
- Exercises 12 h
- Home problem solving 100 h

Learning Outcomes: After the course, the student will be able to:
- Derive transport equations from the entropy production
- Solve the Nernst-Planck equation in several different cases
- Evaluate and solve transport problems on electrodes
- 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:** [https://mycourses.aalto.fi/course/search.php?search=CHEM-E4235](https://mycourses.aalto.fi/course/search.php?search=CHEM-E4235)

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

**Grading Scale:** Fail, 1 – 5

**Registration for Courses:** WebOodi

**Language of Instruction:** English

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

**Responsible teacher:** Tanja Kallio

**Level of the Course:** Master studies

**Teaching Period:** II

**Workload:** 135 h in total
- Lectures 12 h
- Laboratory work 40 h
- Homework 80 h
- Exam 3 h

**Learning Outcomes:** After the course, the student will be able to:
- Name the most common Galvanic cell types and applications
- Apply electrochemical theories for understanding the behavior of galvanic cells
- Apply electrochemical analysis methods for investigation of galvanic cells

**Content:** Different type of Galvanic cells are presented. The students are 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](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.

**Grading Scale:** Fail, 1 – 5

**Registration for Courses:** WebOodi

**Language of Instruction:** English

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**★ 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, 135 h in total.

**Learning Outcomes:** After the course, the student will be able to:
- Search for relevant literature on a given topic and critically evaluate scientific articles
- Write a clear and logical literature review
- Draw conclusions from results obtained and from results presented in the literature
- Compare results with the literature
- 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
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: Fail/pass

Registration for Courses: WebOodi

Language of Instruction: 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, 135 h in total.

Learning Outcomes: After the course, the student will be able to:
- Search for relevant literature on a given topic and critically evaluate scientific articles
- Write a clear and logical literature review
- Draw conclusions from results obtained and from results presented in the literature
- Compare results with the literature
- 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

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

Responsible teacher: Ari Koskinen

Level of the Course: Master studies

Teaching Period: I

Workload: 135 h in total
- 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.
- 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.
- Have deeper understanding on natural products (secondary metabolites), their structures, occurrence, significance, classification, and biosynthesis.

Content: Asymmetric synthesis: classification, reaction types, mechanisms. Methods for determining enantiopurity; general methods for asymmetric induction. Reactions of carbonyl
Compounds and olefins. Natural products classified according to the classes: their occurrence, biosynthesis and synthesis: sugars, amino acids, nucleic acids, polyketides, terpenes, alkaloids.

**Assessment Methods and Criteria:** Lectures and seminar presentation.

**Study Material:** Koskinen, Asymmetric Synthesis of Natural Products, Wiley & Sons, 2012.

**Substitutes for Courses:** CHEM-E4245 Natural Product Chemistry or CHEM-E4125 Asymmetric Synthesis

**Course homepage:** [https://mycourses.aalto.fi/course/search.php?search=CHEM-E4295](https://mycourses.aalto.fi/course/search.php?search=CHEM-E4295)

**Prerequisites:** CHEM-E4195 Selectivity in Organic Synthesis or equivalent

**Grading Scale:** Fail, 1 – 5

**Registration for Courses:** WebOodi

**Language of Instruction:** English

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**CHEM-E4305 Organometallic Chemistry (5 cr)**

**Responsible teacher:** Pekka Joensuu

**Level of the Course:** Master studies

**Teaching Period:** II

**Workload:** 135 h in total
- Lectures 24 h
- Problem sessions 10 h
- My Own Reaction 20 h
- Portfolio 30 h
- Independent homework 50 h

**Learning Outcomes:**
After the course:

- 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 and nucleophilicity, ligand strength or exchange. The 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.

**Study Material:**

**Substitutes for Courses:** KE-4.4120 Organic
Synthesis. A part of the course CHEM-E4265 Advanced Synthesis (10 cr)

Course homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E4315

Prerequisites: CHEM-E4195 Selectivity in Organic Synthesis or equivalent

Grading Scale: Fail, 1 – 5

Registration for Courses: WebOodi

Language of Instruction: English

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

Responsible teacher: Jari Koskinen

Status of the Course: Compulsory for Functional Materials students.

Level of the Course: Master Studies

Teaching Period: I

Workload: 135 h in total
- Lectures 22 h (5 x 4 h +1 x 2 h):
- Term Paper Presentations & opposing 4 h (2 x 2 h)
- Exercises 10 h (5 x 2 h):
- Independent study time 40 h
- Term Paper (group project) 35h
- Exam preparation + Exam 15 h +4 h

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

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, magnetostrictive & 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:

Substitutes for Courses: MT-0.2101 Maeriaalien fysiikka (5 op)

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E5100

Prerequisites: BSc with at least 10 cr of physics. Students with B.Sc. from Aalto, the credits should include PHYS-A2140 Aineen rakenne (CHEM)

Grading Scale: Fail, 1 – 5

Registration for Courses: WebOodi

Language of Instruction: English

CHEM-E5105 Powder Metallurgy and Composites (5 cr)

Responsible teacher: Mikhail Gasik

Status of the Course: Functional materials specialty courses

Level of the Course: Master studies

Teaching Period: I-II

Workload: 135 h
- Lectures 12 h
- Independent work 120 h
- Exam 3 h


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, MT-0.6131 Powder Metallurgy and Composite Materials P.
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: 135 h in total
- 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 Sovellettu materiaali-tiede.

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

Prerequisites: CHEM-E5100 Solid State Materials and Phenomena.

Grading Scale: Fail, 1 – 5.

Registration for Courses: WebOodi

Language of Instruction: English

CHEM-E5115 Microfabrication (5 cr)

Responsible teacher: Samuli Franssila
Status of the Course: Elective course in the following majors: Functional materials, Advanced materials and photonics, Micro- and nanosciences, and Biosensing and bioelectronics.
Level of the Course: Master-level
Teaching Period: IV-V
Workload: 135 h in total
- 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 micro devices, and able to analyze fabrication processes of complex silicon microdevices.


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 Micro-systems (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, and 60% on exam (bonus possibility).

**Registration for Courses:** WebOodi.

**Language of Instruction:** English

**Further Information:** The course is primarily intended for students majoring in the following subjects: Functional materials, Advanced materials and photonics, Micro- and nanosciences, and Biosensing and -electronics. If more than 40 students enroll, students with the above-mentioned majors have priority.

**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:** 135 h in total
- Lectures 22 h (5 x 4 h + 1 x 2h)
- Poster Sessions 4 h (2 x 2 h)
- Exercises 10 h (5 x 2 h)
- Independent study 40 h
- Poster project 39 h
- Exam preparation 20 h

**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 determine the suitable characterization methods at nanoscale and can analyze 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 macroscale 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. 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 - Synthesis, Properties, and Applications
- Handouts and selected articles from scientific literature.

**Course Homepage:**

**Prerequisites:** Completed B.Sc.

**Grading Scale:** Fail, 1 – 5

**Registration for Courses:** WebOodi

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**CHEM-E5125 Thin Film Technology (5 cr)**

**Responsible teacher:** Jari Koskinen

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

**Level of the Course:** Master studies

**Teaching Period:** III

**Workload:** 135 h in total
- 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 property characterization methods.
- Is familiar with the dependence of thin films structure and properties to the critical coating parameters.
- 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](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 chosen to the course if enrolled in time.

**Language of Instruction:** English

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

**Responsible teacher:** Samuli 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-IV

**Workload:** 135 h in total – student selects one lab project from offered projects.

Each project:

- Lectures (introduction and project descriptions) 4 h
- Demonstration 4 h
- Reading scientific papers 15 h
- Research Plan 10 – 15 h
- Experimental work 48 h
- Analysis of the results 10 h
- Reporting + presenting the results 30 h

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

- Design a series of laboratory experiments
- Carry out complete experimental investigation including design, equipment building, data acquisition and analysis
- Present the results in a logical manner

**Content:** Students choose two experimental lab projects. Projects vary from year to year and from period to period. Projects are 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, and nanosurfaces.

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

**Study Material:** Handouts

**Course Homepage:** [https://mycourses.aalto.fi/course/search.php?search=CHEM-E5130](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:** 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:
- Contact sessions 12 h
- Project Work 56 h
- Individual study (preparation for & reflections of contact sessions, short reports) 63 h

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 technological solutions by getting inspiration following:
- Definition of biomimetics
- Material properties, systems and environments
- Material charts for material selection
- Functionalities 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.


Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E5135

Grading Scale: Fail, 1 – 5

Registration for Courses: WebOodi

Language of Instruction: 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: 135 h in total
- Contact teaching
- 5 laboratory works
- Independent work
- Reporting

Learning Outcomes: After passing this course, the student:
- Knows the capabilities and limitations of major materials and surface characterization techniques
- Can select the most proper materials characterization methods for particular sample
- Can critically evaluate the material characterization methods used in research papers
- 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: Seminars, 5 laboratory exercises, written reports and examination.


Substitutes for Courses: MT-0.3101 Materiaalitutkimusmenetelmät (5 cr)

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=MT-0.3101
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 one's 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 cells, wind turbines, electrolyzers, hydrogen storage, fuel cells, and batteries) and develop thinking to produce new material solutions and eco-designs for these applications.

Assessment Methods and Criteria: Workshops, flip the classroom, team tasks and innovation projects.

Study Material:

Course homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E5145

Substitutes for Courses: MT-0.6141

Erikoismateriaaliratkaisut P (5 cr)
Prerequisites: B.Sc.
Grading Scale: Fail, 1 - 5.
Registration for Courses: WebOodi
Language of Instruction: English
Further Information: Forms a continuum with other energy courses of the CHEM-school: CHEM-E4255 Electrochemical energy conversion (recommended participation before this course) and CHEM-E5215 Materials for Nuclear Power Plants.

★ CHEM-E5200 Personal Research Assignment in Functional Materials V (V) (5-10 cr)
Responsible teacher: Samuli 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-level
Teaching Period: I, II, III, IV, V
Workload: Individual project 135 h
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 scientific/technical research problem given by the supervisor. Variable topics offered by responsible teachers.

**Assessment Methods and Criteria:** 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 31 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 WebOodi 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:** English

**Further Information:** The topic must be related to functional materials. Course can be taken twice, with 2 different topics (5 cr. each). Projects are available on a running basis throughout the year (see MyCourses). Projects start whenever student and supervisor agree. Expected duration 1-3 months, including report.

**CHEM-E5205 Advanced Functional Materials P (5 cr)**
**Responsible teacher:** Simo-Pekka Hannula
**Status of the Course:** Functional materials specialty courses

**Level of the Course:** Master studies, 2nd year, or doctoral studies

**Teaching Period:** I - II

**Workload:** 135 h in total
- 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

**Substitutes for Courses:** MT-0.6024 Uudet materiaalit L (V) (5 op)

**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:** English

**CHEM-E5210 Group Research Assignment in Functional Materials V (V) (5 cr)**
**Responsible teacher:** Samuli 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:** 135 h in total
- Contact sessions 5 x 3 h = 15 h
- Group project 120 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:** Research project

**Assessment Methods and Criteria:** Group activities, oral presentations and reflective journal.
Study Material: Handouts, scientific articles.
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E5210
Prerequisites: Compulsory courses of Functional materials.
Grading Scale: Fail, 1 - 5.
Registration for Courses: WebOodi
Language of Instruction: 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, also for doctoral studies
Teaching Period: III - IV
Workload: 135 h in total
- 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 team.
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: 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, also for doctoral studies.
Teaching Period: I - II
Workload: 135 h in total
- 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 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: English

CHEM-E6100 Fundamentals of Chemical Thermodynamics (5 cr)
Responsible teacher: Pekka Taskinen
Status of the Course: Compulsory course in Sustainable Metals Processing major.
Level of the Course: Master level
Teaching Period: I
Workload: 135 h in total
- Lectures 24 h
- Tutorials 24 h
- Project (home) work 45 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, and 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: English

CHEM-E6105 Thermodynamics of Solutions (5 cr)

Responsible teacher: Pekka Taskinen
Status of the Course: Compulsory course in Sustainable Metals Processing major.
Level of the Course: Master level
Teaching Period: III-V
Workload: 135 h in total
- 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 minimizer),
- 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 minimization techniques for the chemical simulations.
Assessment Methods and Criteria:
Lectures, tutorials and guided assessments in a computer class, project work in groups from a selected topic, and 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: English

CHEM-E6115 Thermodynamics of Modeling and Simulation (5 cr)

Responsible teacher: Pekka Taskinen
Status of the Course: Compulsory course in Sustainable Metals Processing major.
Level of the Course: Master level
Teaching Period: III-IV
Workload: 135 h in total
- 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
- Analyze 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 class, project work in groups from a selected topic, and 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: English

CHEM-E6130 Metal Recycling Technologies (5 cr)

 Responsible teacher: Rodrigo Serna Guerrero

Level of the Course: Master

Teaching Period: II

Workload: 135 h in total
- 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
- Systematically 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 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


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: 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: II

Workload: 135 h in total
- Lectures 24 h
- Tutorials 24 h
- Project (home) work 45 h
- Independent studies 42 h

Learning Outcomes: After the course, the student:
- Will understand the fundamental properties of minerals and their relevance in mineral enrichment and recycling operations
- Generate material balances from experimental observations and analyze process performance
- Understand the principles of grinding, liberation and classification,
- Understand the properties of solid particles and slurries and their means of transport
- Understand basic mineral properties and
how to exploit them in enrichment operation technologies,
- Understand the effects of liberation on processing and recycling from a product-centric viewpoint


**Assessment Methods and Criteria:**
- Tutorials and exercises in a computer class
- Assignments and presentations
- Independent study and exam

**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:**

**Prerequisites:** CHEM-E6140 Fundamentals of Minerals Engineering and Recycling

**Grading Scale:** Fail, 1 – 5

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

**Language of Instruction:** English

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**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:** 135 h in total
- 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 economic 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.

**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; Kelly: Introduction to mineral processing, Australian Mineral Foundation

**Course Homepage:**

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**CHEM-E6155 Minerals Engineering Project Work (5 cr)**

**Responsible teacher:** Rodrigo Serna Guerrero

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

**Level of the Course:** Master level

**Teaching Period:** III-V

**Workload:** 135 h in total
- Lectures 24 h
- Tutorials 24 h
- Project (home) work 54 h (incl. 20 h project-focused tutorials)
- Independent (group) studies 33 h

**Learning Outcomes:** After the course the student will
- Understand the process of plant design for primary or secondary feed (project work)
- Create flowsheets with material balances from experimental data
- Make the dimensioning of a major piece of equipment in a processing plant
- Evaluate CAPEX and OPEX costs for the design
- Make and evaluate simplified questionnaires and quotations

**Content:** Mineral products and pricing, sizing and optimum design of equipment, project phases, project scheduling, and prefeasibility study-level design work

**Assessment Methods and Criteria:** Lectures, tutorials and guided assignments in a computer class, project work in groups from a selected topic, and independent studies and exam

**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 either replacement of the course MT-0.3406 Kierrätystekniikan erikoistyöt (5 op) or MT-0.3411 Kierrätystekniikan laboratoriotyöt (5 op).

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**Course Homepage:**

**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:** English

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**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:** 135 h in total
- Lectures 24 h
- Tutorials and exercises 24 h
- Project work 45 h
- Independent studies 38 h
- Exam 4 h

**Learning Outcomes:**
- Can describe the basic unit processes and technologies in ferroalloys and steelmaking production,
- Can describe the basics of sulphide smelting and the key processing technologies used for non-ferrous metals,
- Knows the fundamentals of solidification and different casting technologies as well as rolling and heat treatment processes,
- Knows the basics 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 focus is in 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, learning diary/diaries, and a written examination.

**Study Material:** Seshadri Seetharaman (ed.): Treatise on Process Metallurgy, Vol. 1 and 3A (selected chapters), 2014, Elsevier; Lecture notes and additional material distributed on the lectures.

**Course Homepage:**

**Grading Scale:** Fail, 1 – 5

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

**Language of Instruction:** 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 (Spring 2018)  
**Workload:** 135 h in total  
- 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), learning diary/diaries, and a written examination  

**Study Material:** Seshadri Seetharaman (ed.): Treatise on Process Metallurgy, Vol. 1 and 2 (selected chapters), 2014, Elsevier; Lecture notes and additional material distributed on the lectures.  

**Course Homepage:**  

**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:** English

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**CHEM-E6180 Fundamentals of Hydrometallurgy (5 cr)**

**Responsible teacher:** Mari Lundström  
**Status of the Course:** Master level major Sustainable Metals Processing  
**Level of the Course:** Master level  
**Teaching Period:** I-II  
**Workload:** 135 h in total  
- 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 flowsheet 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, and flowsheet modeling with HSC Sim  

**Assessment Methods and Criteria:**  
Lectures, tutorials and exercises in a computer class, process selection casework in selected topics, and report preparation  

**Course Homepage:**  
CHEM-E6185 Applied Electrochemistry and Corrosion (5 cr)

Responsible teacher: Mari Lundström
Status of the Course: Master level major Sustainable Metals Processing
Level of the Course: Master level
Teaching Period: III-IV
Workload: 135 h in total
- 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, and electrochemistry of corrosion. Experimental design using Modde-software, electrochemical research methods, experiments and data analysis, and corrosion engineering in process equipment

Assessment Methods and Criteria: Lectures, tutorials and exercises in a computer class, laboratory exercises, and corrosion problem-solving cases.

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E6185

Prerequisites: CHEM-E6180 Fundamentals of Hydrometallurgy

Grading Scale: Fail, 1 – 5
Registration for Courses: WebOodi
Language of Instruction: English

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

Responsible teacher: Mari Lundström
Status of the Course: Master level major Sustainable Metals Processing
Level of the Course: Master level
Teaching Period: IV-V
Workload: 135 h in total
A problem based course:
- 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, and preparation of a flowsheet from raw material to product

Assessment Methods and Criteria: Lectures, tutorials and exercises in a computer class, laboratory exercises, and HSC Sim flow-sheet design

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E6195
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: 135 h in total
- Lectures 24 h
- Tutorials 24 h
- Project (home) work 54 h (incl. 20 h project-focused tutorials)
- Independent (group) studies 30 h
- Exam 3 h
Learning Outcomes: After the course the students
- Understand the process of plant design for primary or secondary feed (project work).
- Create flowsheets with material balances from experimental data.
- Make the dimensioning of a major piece of equipment in a processing plant.
- Evaluate CAPEX and OPEX costs for the design and overall feasibility and profitability of the process.
- 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 prefeasibility study-level design work.

Assessment Methods and Criteria: Lectures, tutorials and guided assignments in a computer class, project work in groups from a selected topic, independent study and a written examination

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.

CHEM-E6210 Individual Research Project, V (V) (5-10 cr)
Responsible teacher: Mikhail Gasik
Level of the Course: Master
Teaching Period: English
Workload: 135 h – 270 h in total (5 – 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

Course homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E6210
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: 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 multidisciplinary forum.

Level of the Course: Master Studies/Doctoral Studies

Teaching Period: IV-V

Workload: 135 h in total
- Workshops 6 x 3 h = 18 h
- Project work 75 h
- Individual studying and reflection 42 h

Learning Outcomes: After the completion of the course the student has
- Learned the main concepts of circular economy and their 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 solve project relevant for industry, including aspects of economic analysis
- Worked in a multidisciplinary team

Content: At this course, the students 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 or system design with constructed business plan. The student groups will compete against each other and then present their projects in front of a panel of experts.

Assessment Methods and Criteria: Workshop tasks, group project and self-evaluation

Handouts and scientific articles.

Course homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E6215

Substitutes for Courses: CHEM-E6135 Planning Exercise in Sustainable Metals Processing

Prerequisites: CHEM-E6120, CHEM-E6125

Grading Scale: Fail, 1 – 5

Registration for Courses: WebOodi

Language of Instruction: English

Further Information: Students from other schools in Aalto are encourage to participate to 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. 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

Teaching Period: I – II

Workload: 270 h in total
- Workshops
- Project team work
- Independent study and reflection
- Seminar

Learning Outcomes:
- The student can share his/her expertise in a multidisciplinary team
- The student can evaluate added value of process, service or product
- The student can present findings in an international seminar
- Creates international network of peers and company representatives

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. Selected projects will be presented at international platform (organized with KTH and NTNU).

Assessment Methods and Criteria: Workshops, project work and individual reflective journals

Study Material: Handouts

Course homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E6225
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: 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 in total
- 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
Strategy transformation and cultural change
Assessment Methods and Criteria: Contact sessions, MOOCs, group tasks
Study Material: Contact session and online material
Course homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E6235

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: 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: 135 h in total
- 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, and modelling and design of unit operations and process simulation techniques.
Assessment Methods and Criteria: Lectures, computer class exercises, mandatory homework assignments, and 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: 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: I-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, and 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, and exam

Study Material:

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

Course Homepage:

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

Language of Instruction: 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: 135 h in total
- Lectures 12 h
- Exercises 36 h
- Homework assignments 40 h
- Other independent studying 45 h

Learning Outcomes: After the course the student
- Knows the importance of thermophysical and transport properties in design of separation processes
- Knows the role of 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, and 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: English

⊗ CHEM-E7115 Experimental Assignments in Chemical Engineering (5 cr)
Responsibility 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: 135 h in total
  - 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, and 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: 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)
Responsibility teacher: Juha-Pekka Pokki
Status of the Course: Compulsory course in Chemical Engineering major.
Level of the Course: Master studies
Teaching Period: III-V
Workload: 135 h in total
  - Lectures 8 h
  - Project work 100 h
  - Other independent studying 25 h
Learning Outcomes: After the course the student
  - Has hands on experience in experimental laboratory work of the selected case
  - Is capable of finding and combining information on various subjects of unit operations and unit processes
  - 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: 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: 135 h in total
- 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
Study Material: Lecture notes, exercise material, hand-outs
Substitutes for Courses: KE-42.4520 Process Modelling - methods and tools L (5 cr) or KE-90.3100 Process Modelling and Simulation (6 cr)
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E7130
Grading Scale: Fail, 1 - 5
Registration for Courses: WebOodi
Language of Instruction: English

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: 135 h in total
- Lectures 18 h
- Project work 72 h
- Other independent studying 40 h
- Exam 5 h

Learning Outcomes: After the course, the
student is able to
- Describe different phenomena (e.g. reactions and mass transfer) in industrial reactors
- Combine rate equations and stoichiometry with balance equations of multiphase reactors
- Apply mass and energy balances for different industrial multiphase reactors and perform calculations using the balances
- Explain the principles of computational calculations of multiphase reactors
- Recognize the applications of different industrial reactor types
- 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 lectures.

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E7135

Prerequisites: CHEM-E7150 Reaction Engineering

Grading Scale: Fail, 1-5

Registration for Courses: WebOodi

Language of Instruction: English

CHEM-E7140 Process Automation (5 cr)

Responsible teacher: Sirkka-Liisa Jämsä-Jounela

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

Level of the Course: Master studies

Teaching Period: I

Workload: 135 h in total
- Lectures 24 h
- Exercises 24 h
- Independent studying, homework/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


Assessment Methods and Criteria: Lectures, exercises, homework, independent study, and exam

Study Material: To be announced later.
CHEM-E7150 Reaction Engineering (5 cr)

Responsible teacher: Yongdan Li

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

Level of the Course: Master studies

Teaching Period: II

Workload: 135 h in total
- Lectures 20 h
- Exercises 14 h
- Assignments 48 h
- Independent work 48 h
- Exam 5 h

Learning Outcomes:
After the course the student
- Knows the principles of heterogeneous catalysis
- Recognizes the steps (diffusion, adsorption/desorption, surface reaction) in heterogeneously catalyzed reactions
- Knows the types of homogeneous catalysis and is able to derive rate equations of acid/base catalyzed homogeneous reactions
- Can derive rate equations based on steps of heterogeneously catalyzed reactions
- Knows the different forms of deactivation of heterogeneous catalysts and can derive rate of deactivation based on the type of deactivation
- Is able to evaluate existence of diffusion limitations in heterogeneously catalyzed reactions
- Can use methods applied for the evaluation of internal and external diffusion limitations in heterogeneous catalysis
- Can combine the rate equations of heterogeneously catalyzed reactions to reactor mass balance equations and use these equations for the construction of simulation model

Content:
- Fundamentals and steps of heterogeneous catalysis
- Reaction mechanisms and rate equations heterogeneously catalyzed reactions
- Reaction mechanisms and rate equations homogeneously catalyzed reactions
- Deactivation mechanisms and rates in heterogeneous catalysis
- Internal and external mass transfer in heterogeneous catalysis
- Coupling of reactor mass balances (pseudohomogeneous model) and rate equations of catalyzed reactions

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

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: 135 h in total
- 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 discussed, assignments, LP optimization of Tennessee Eastman, and optimal preventive maintenance of feeding connections of a chemical plant using dynamic programming

**Assessment Methods and Criteria:** Lectures, exercises, assignments, independent study, and exam

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

**Substitutes for Courses:** KE-90.2500 Basics in Production Planning and Control (6 cr)

**Course Homepage:** [https://mycourses.aalto.fi/course/search.php?search=CHEM-E7155](https://mycourses.aalto.fi/course/search.php?search=CHEM-E7155)

**Prerequisites:** To be announced later.

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

**Registration for Courses:** WebOodi

**Language of Instruction:** English

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**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:** 135 h in total
- Lectures 24 h
- Exercises 36 h
- Project work 35 h
- Laboratory exercise 10 h
- Other independent studying 30 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, slurries), 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, and fluid flow measurements.

**Assessment Methods and Criteria:** Lectures, exercises at computer class, project work in groups from a selected topic, laboratory exercise in pairs or small groups, and independent study

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**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:** 135 in total
- Lectures 24 h
- Exercises 24 h
- Assignments + independent study 83 h
- Exam 4 h

**Learning Outcomes:** After completing the course, the student:
- Understands the main principles of the
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. Homework: Experimental modelling of a distillation column, estimation using a Kalman filter

Assessment Methods and Criteria: Lectures, exercises, assignments, independent study and exam

Study Material: To be announced later.

Course homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E7165

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: English

CHEM-E7170 Design project in Chemical Engineering, part A (5 cr)

Responsible teacher: Pekka Oinas

Level of the Course: Master studies

Teaching Period: IV-V

Workload: 135 h in total
- Lectures 4 h
- Exercises 4 h
- Project work 127 h

Learning Outcomes: After the course, 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:
- 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:
- Project start-up, market study and plant location, process alternatives and comparison of process alternatives
- Selecting the process alternatives; process design, PFD, material and energy balance, equipment sizing, equipment lists, emissions, environmental and safety of the process

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

Study Material: Oinas and Golam, Design project guide

Course homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E7170

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: 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:** 135 h in total  
- 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:
- Can acquire the basic knowledge of safety issues in chemical process industry  
- Can identify the hazard of chemicals and chemical processes  
- Can identify the risk of damages and accidents in chemical process industry and method of prevention  
- Can apply the hazard and safety analysis methods  
- Can identify fires and explosions, and design the precautions  
- Understands the methods and techniques in chemical process safety  
- Understand the basic sustainability concepts  
- Knows the basis of the different measures to assess sustainability  
- Is able to conduct a LCA and critically interpret the results from sustainability assessment tools  
- Can apply the principles of an environmental impact assessment process

**Content:**  
Introduction of process safety, toxicology and industrial hygiene, fires and explosions, reliefs and relief equipment sizing, hazards identification methods, active and passive safety, inherent safety, development of safety management and culture, safety in maintenance and electrical equipment, introduction to circular economy, sustainability principles and strategies, sustainability vs. eco-efficiency, and sustainability assessment tools.

**Assessment Methods and Criteria:** Lectures, exercises, seminar and exam

**Study Material:** Lecture note, books

**Course homepage:** https://mycourses.aalto.fi/course/search.php?search=CHEM-E7175

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

**Language of Instruction:** English

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**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:** 185 h in total  
- Lectures 4 h  
- Exercises 4 h

- Project work 128 h
- Total: 135 h

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

**Content:** Continuation of DP part A. Project work is done in same team of 5-6 students. The design project in 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

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

**Study Material:** Oinas and Golam, Design project guide
Course homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E7180
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: English
Further Information: The design project course Part B is the continuation of Part A; Part B cannot be taken without successful completion of Part A.

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: 135 h in total
- Lectures and exercises, 20 - 24 h
- Teamwork (preparation, meetings) 80 h
- Learning diary 8 h
- Individual work 20 - 24 h
Learning Outcomes: After the course the student can:
- Compose a detailed design for a plant or part of a plant for the next stage (investment proposal)
- Assess the techno-economic feasibility of the selected industrial operation
- Describe the full chain from R&D to plant start-up
- Analyze the business, competition and markets with different methods
- Apply business analysis methods (Five forces, PESTEL, business model canvas)
- Assess, calculate and analyze the financial outcomes of businesses
- Present a business model for the selected process
- Describe long-range plan for business development
- Possess ‘out-of-the-box’ mindset for design of industrial operations
- Carry out successful negotiations

Content: The course format comprises of the following elements: lectures, 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
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: 135 h in total
- 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 Proibus, 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

Course homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E7195

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: English

CHEM-E8100 Organic Structural Analysis (5 cr)
Responsible teacher: Jari Koivisto
Level of the Course: Master studies
Teaching Period: I
Workload: 135 h in total
- Lectures 28 h
- Exercises 18 h
- Instrument demonstrations 6 h
- Home problem solving 13 h
- Independent homework 66 h
- Exam 4 h

Learning Outcomes:
After the course, the student will be able to
- Interpret MS, IR and NMR spectra
- Solve structures of organic molecules based on MS, IR and NMR spectra
- Describe the functional principles of the MS, IR and NMR spectrometers

Content: The objective is to learn how to use mass spectrometry (MS), infrared spectroscopy (IR) and nuclear magnetic resonance spectroscopy (NMR) in the structural determination and identification of organic compounds.

Assessment Methods and Criteria: Lectures and exercises. The course includes homework and instrument demonstrations. Final exam.

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E8100
Grading Scale: Fail, 1 – 5
Registration for Courses: WebOodi
CHEM-E8105 Enzymatic and Biomimetic Catalysis (5 cr)

Responsible teacher: Jan Deska
Level of the Course: Master studies
Teaching Period: IV
Workload: 135 h in total
- Lectures 24 h
- Seminars 8 h
- Home problem solving 20 h
- Independent homework 80 h

Learning Outcomes: After the course, the student will have deeper understanding on
- Basic biosynthetic principles
- Mechanisms of enzymatic activation
- Biocatalysis in synthesis
- Semi- and mutasynthesis
- Biomimetic organocatalysis

Content: The knowledge of the principle activation mechanisms in biosynthesis helps 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.

Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E8105
Grading Scale: Fail, 1 – 5
Registration for Courses: WebOodi
Language of Instruction: 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: 135 h in total
- Lectures and seminars 18 h
- Laboratory 70 h
- Reporting (written and oral) 24 h
- Assignments 23 h

Learning Outcomes: After the course, the students:
- Will be able to perform basic microbiology and biochemistry laboratory experiments
- Can apply methods used in molecular biology laboratories
- Can identify and use the appropriate means for isolation, separation, purification and identification of (small) organic molecules
- 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, Immunoblotting)
- Synthesis of organic compounds and their isolation/purification based on chromatography and recrystallization techniques
- Spectroscopic and chromatographic characterization of compounds and evaluation of their purities

Assessment Methods and Criteria: Experimentation, planning, practical implementation, reporting, and assignments
Study Material: Materials distributed during the course
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E8110
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 attendance, completion of the experimental work (30%), and 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:** English

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

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**CHEM-E8115 Cell Factory (5 cr)**

**Responsible teacher:** Alexander Frey  
**Level of the Course:** Master studies  
**Teaching Period:** III  
**Workload:** 135 h in total  
- Lectures 24 h  
- Project work 40 h  
- Self-study 67 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 synthesis and modification of enzymes, therapeutic proteins, biochemicals and secondary metabolites. It is located at the interface of biochemistry, microbiology, cell biology and metabolic engineering. The course aims at the analysis, understanding and recombining of nature's 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 mammalian cells. A project work accompanies the lectures where students design a cell factory.

**Assessment Methods and Criteria:** Lectures, project work and self-study  
**Study Material:** Materials distributed during the course. Additional reading material: Glick, Pasternack, Molecular Biotechnology (4th edition, 2013)

**Course Homepage:** [https://mycourses.aalto.fi/course/search.php?search=CHEM-E8115](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%)

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**CHEM-E8120 Cell Biology (5 cr)**

**Responsible teacher:** Alexander Frey  
**Level of the Course:** Master studies  
**Teaching Period:** II  
**Workload:** 135 h in total  
- Lectures 24 h  
- Assignments 27 h  
- Self-study 80 h  
- Exam 4 h  

**Learning Outcomes:** After the course, the students will be able to:
- Appreciate the different levels of biological organization, from molecules to cells  
- Understand the biological processes critical for cellular functioning  
- Can integrate the different processes into the proper cellular context  
- Assess the function of regulatory pathways and networks at the cellular level  
- Describe the general principles of gene organization and expression  
- Critically analyze experimental data

**Content:** The course aims at providing the understanding of essential cellular processes (DNA replication, gene expression, protein targeting and transport, protein modification, membrane transport, secretion and endocytosis, cell signaling, regulation of cell death, cell cycle). The course focuses on eukaryotic organisms.

**Assessment Methods and Criteria:** lectures, assignments and self-study  
**Study Material:** Molecular Biology of the Cell, 6th edition, Garland Sciences
**Course Homepage:**

**Prerequisites:** The course presupposes basic knowledge and competences in the field of Biosciences, which are in content, scope and quality similar to those offered in CHEM-A1310 and CHEM-C2300.

**Grading Scale:** Fail, 1 – 5 grading is based on examination (75%) and assignments (25%)

**Registration for Courses:** WebOodi

**Language of Instruction:** 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:** 135 h in total
- Lectures 24 h
- Assignments 24 h
- Other independent studying 83 h
- Exam 4 h

**Learning Outcomes:** The student is able to:
- Describe the motivation for synthetic biology as a development in the technical use of biology
- Demonstrate aspects of biotechnology that currently pose limitations for its industrial use and to analyze how synthetic biology can be applied as a solution.
- Apply the concepts of synthetic biology for the design of biological systems.
- List current research questions in the field.


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

**Study Material:** To be announced later

**Course Homepage:**

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

**Registration for Courses:** WebOodi

**Language of Instruction:** English

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**CHEM-E8130 Medicinal Chemistry (5 cr)**

**Responsible teacher:** Jan Deska

**Level of the Course:** Master Studies

**Teaching Period:** II

**Workload:** 135 h in total
- 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:
- How pharmaceuticals are discovered and optimized
- How drugs exhibit desired and undesired effects
- 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 ‘biologica'. 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.

**Study Material:** Handout is provided. Course based on G. Klebe, Drug design – Methodology, concepts and mode-of-action, Springer, 2013

**Course homepage:**

**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: English

CHEM-E8135 Microfluidics and BioMEMS (5 cr)

Responsible teacher: Samuli Franssila
Status of the Course: Elective course
Level of the Course: Masters and doctoral
Teaching Period: III-IV
Workload: 135 h in total
- 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 behavior 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: English

CHEM-EV Course with Varying Content (V) (0 cr)

Responsible teacher: Tapani Vuorinen
Level of the Course: Master studies
Teaching Period: I-V
Workload: Varies with the extent of the course.
Learning Outcomes: Will be agreed separately.
Content: The study period can include topics not covered by the regular curriculum. The contents and requirements for the individual study element have to be agreed upon with the teacher in charge.
Assessment Methods and Criteria: Will be agreed separately.
Study Material: Will be agreed separately.
Grading Scale: Pass/Fail, 1 – 5
Registration for Courses: WebOodi
Language of Instruction: 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:** 135 h in total  
- Lectures 10 x 2 hour = 20 h  
- Individual work 20 h  
- Seminars 2 x 16 hours = 32 h  
- 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.

**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:** English

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

**Responsible teacher:** Eero Kontturi  
**Level of the Course:** Doctoral Studies  
**Teaching Period:** IV-V, lectured in even years  
**Workload:** 8 cr, about 213 hours in total

**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


**Prerequisites:** M.Sc. (Tech.) degree or equivalent level degree

**Grading Scale:** Fail, 1 – 5

**Registration for Courses:** WebOodi

**Language of Instruction:** English

**Further Information:** -

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**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 (even years)

**Workload:** 7 cr = 189 h in total

**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:** English

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**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:** 81 h in total

- 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:** English

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**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:** 81 h - 189 h

- Lectures 10 h
- Seminar 10 h
- Independent studies depending on credits

**Learning Outcomes:** The aim of the course is 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

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

**Language of Instruction:** English

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**CHEM-L2130 Research Seminar on Electrochemistry (12 cr)**

**Responsible teacher:** Lasse Murtomäki

**Evaluation:** hyv - Courses

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

**Responsible teacher:** Ari Koskinen

**Level of the Course:** Doctoral studies

**Teaching Period:** I-V

**Workload:** 324 h in total

- Lectures 26 h
- Independent work and reflection 298 h

**Learning Outcomes:** The students learn to critically evaluate, present, and discuss research topics in the field of organic chemistry and its adjoining fields.

**Content:** The seminars deal with special topics of organic chemistry concerning the degree requirements of post-graduate students. The research methodology of organic chemistry is introduced by guest lecturers.

**Assessment Methods and Criteria:** Lectures, seminar presentations and homework.

**Study Material:** Material delivered on lectures

**Prerequisites:** Master’s degree in organic chemistry.

**Grading Scale:** Pass/Fail

**Registration for Courses:** WebOodi

**Language of Instruction:** English

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**CHEM-L2150 Biofuels and Biorefineries (5 cr)**

**Responsible teacher:** Yongdan Li

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

**Teaching Period:** Intensive course, next time in August 2019

**Workload:** 135 h in total
- Contact teaching 35 h
- Independent work 100 h

Learning Outcomes: A course with varying content. The aim of the course is to give an overview of the present state of art in biorefineries and conversion of biomass.

Content: A course with varying content. Current topics related to biorefineries and biofuels.

Assessment Methods and Criteria: Written report as the major output

Study Material: Materials to be announced.

Substitutes for Courses: CHEM-L2100

Course Homepage: MyCourses

Grading Scale: Fail, 1 – 5

Registration for Courses: WebOodi

Language of Instruction: English

CHEM-L2200 Advanced Microfabrication V(V) (8 cr)

Responsible teacher: Samuli Franssila

Status of the Course: Doctoral CHEM, ELEC, SCI, also for master's students

Level of the Course: Doctoral / Master studies

Teaching Period: I-II, lectured odd years

Workload: 213 h in total

- 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: MT-0.7072 Advanced Microtechnology P V 8 op

Prerequisites: Microfabrication CHEM-E5115 strongly recommended

Grading Scale: Fail, 1 – 5

Registration for Courses: WebOodi

Language of Instruction: English

Further Information: Lectured alternate years with CHEM-L2210 Thin Film Technology (8cr) 2017: Advanced microfabrication, 2018: Advanced Thin film technology doctoral course

CHEM-L2210 Advanced Thin Film Technology (8 cr)

Responsible teacher: Samuli Franssila; Jari Koskinen

Status of the Course: Doctoral CHEM, ELEC, SCI, also for master's students

Level of the Course: Doctoral / Master studies

Teaching Period: I-II, lectured even years, next time 2018

Workload: 213 h in total

- Lectures 20 h
- Seminars 10 h
- Preparation for seminar talks 69 h
- Project(s) 90 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: English

Further Information: Lectured alternate years with CHEM-L2200 Advanced Microfabrication V (8 cr). Thin films next time in 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
sustainable metals processing.

**Assessment Methods and Criteria:** Active participation (min 80 %) in lectures (3 cr). Seminar report (5 cr).

**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:** English

**CHEM-L2230 Research Seminar in Functional Materials 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 (5 cr).

**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:** English

**CHEM-L4010 Teaching Partner Chem (1-5 cr)**

**Responsible teacher:** Maria Clavert

**Level of the Course:** Targeted for academics at Aalto University School of Chemical Engineering. Requirement: motivation and capability for planning, implementing and evaluating teaching and learning experimentations. Elective pedagogical course.

**Teaching Period:** I-V (the course is available throughout the academic year)

**Workload:** 27 h – 135 h in total

- 1/3 Planning
- 1/3 Experiment
- 1/3 Evaluation

**Learning Outcomes:** After the course, the participant can:

- Make a student-centered teaching plan
- Apply a student-centered approach to choosing intended learning outcomes, core content, learning activities, workload and assessment methods in course design
- Utilize PBL-oriented methods in own teaching
- Utilize a storyline technique to support working life skill development
- Collect and utilize student feedback in teaching development

**Content:**

- Planning, implementing, and evaluating teaching and learning experimentations
- Student-centered approach to course (and program) design
- Problem-based learning
- Storyline technique and working life skills
- Giving, receiving, and utilizing feedback on teaching and learning

**Assessment Methods and Criteria:** The course is based on planning, implementing, and evaluating teaching and learning experimentations. Working methods: mentoring. Suitable for individuals and small groups.

**Study Material:** Relevant study materials are provided according to the needs of the experimentations.

**Course Homepage:** [https://inside.aalto.fi/display/fitost/Valinnaiset+kurssit](https://inside.aalto.fi/display/fitost/Valinnaiset+kurssit)

**Grading Scale:** Pass/fail

**Registration for Courses:** Contact Maria Clavert (maria.clavert@aalto.fi, 0505213044)

**Language of Instruction:** Suomi/English

**Further Information:** Design Factory and Aaltonaut are available as platforms for the teaching and learning experimentations: [www.designfactory.aalto.fi](http://www.designfactory.aalto.fi), [www.aaltonaut.aalto.fi](http://www.aaltonaut.aalto.fi)

**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. A doctoral candidate understands the role of support mechanisms, changing rules, 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, netmetering, 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) + corresponding 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: English

Further Information: The course is targeted to doctoral students, primarily to the students in the SELECT+ Programme. The maximum number of participants in the course is 25 students. Applications required.