Syllabus

MSc Chemical Engineering (M-CHE)

MME Track

2014 / 2015

	Molecular & Materials Engineering (M1)			
	Block 1A	Block 1B	Block 2A	Block 2B
Core modules	**AMM Molecular and Biomolecular CT** (5 EC, Huskens)	**AMM Organic Materials Science** (5 EC, Vancso)	**AMM Inorganic Materials Science** (5 EC, Rijnders)	**AMM Applications** (5 EC, Lammertink)
	AMM Characterization (5 EC, Schön)		**AMM Project Organic Materials** (5 EC, Hempenius)	**AMM Project Inorg. Materials & Mol. CT** (5 EC, Lai/Koster)
Electives (scheduled)	**Colloids and Interfaces** (5 EC, Lammertink)	**Advanced Molecular Separations** (5 EC, de Vos/Schuur)	**Physical Organic Chemistry** (5 EC, Jonkheijm)	**Biochemistry** (5 EC, Poot)
	Polymers & Materials Science Practice (3 EC, Hempenius)	**Thermodynamics and Flowsheeting** (5 EC, van der Ham)	**Biomedical membranes and (bio)artificial organs** (5 EC, Stamatialis)	**Catalysis in the Process Industry** (5 EC, Seshan)
	Labcourse Chemistry for Biomed. Appls. (5 EC, Grijpma)	**Batteries, Fuel Cells & Electrolysers** (5 EC, Bouwmeester)	**Transport in Turbul. Chem. React. Flows** (3.6 EC, Kok)	**Photocatalysis Engineering** (5 EC, Mul)
	Membranes for Gas Separation (5 EC, Nijmeijer/Bouwmeester ea)		**Elastomeric Technology** (5 EC, Blume)	
	Theory of Phase Equilibria (5 EC, van der Hoef)	**Catalysis for Sustainable Techns.** (5 EC, Seshan)		
	Controlled Drug and Gene Delivery (5 EC, Metselaar)	**Biomedical Materials Engineering** (5 EC, Grijpma/Poot)		
Electives (not scheduled)	**Lab Course Advanced Materials** (5 EC, ten Elshof)			
	Chemistry of Inorganic Materials and Nanostructures (5 EC, ten Elshof)			
	Imperfections (5 EC, Koster)			
	Polymer Physics (5 EC, Vancso)			
	Organic Chemistry of Polymers (5 EC, Dijkstra)			
	Bioinspired Molecular Engineering (5 EC, Jonkheijm)			
	Advanced Ceramics (5 EC, Winnubst)			
	Contract Research (5 EC, Betlem)			
	Capita selecta … (5 EC)			

	Molecular & Materials Engineering (M2)			
	Block 1A	Block 1B	Block 2A	Block 2B
Core modules	**Internship** (20 EC, Folkers)			
	Final project MSc (45 EC)			

Block structure

The MSc Chemical Engineering program is a 2-year program (120 ec). As all other BSc and MSc programs at the University of Twente the year starts in September and ends at the beginning of July. Each year is divided into 4 blocks, which are referred to as 1A, 1B, 2A and 2B.

Block		**Weeks**	**Dates**
Block 1A	Instruction weeks	36 - 43	Sept 1 - Oct 24
	Exam weeks	44, 45	Oct 27 - Nov 7
Block 1B	Instruction weeks	46 - 51, 2, 3	Nov 10 - Dec 19, Jan 5 - Jan 16
	Exam weeks	4, 5	Jan 19 - Jan 30
Block 2A	Instruction weeks	6 - 8, 10 - 14	Febr 2 - Febr 20, March 2 - April 3
	Exam weeks	15, 16	April 6 - April 17
Block 2B	Instruction weeks	17 - 25	April 20 - June 19
	Exam weeks	26, 27	June 22 - July 3

Core modules

193700020		AMM – Molecular and Biomolecular Chemistry and Technology
5 ec	1A	
Lecturer(s)		Prof.dr. J.J.L.M. Cornelissen, prof.dr.ir. J. Huskens
Objective		Molecular recognition is an essential phenomenon in living systems as well as in artificial ones. It describes the specific interaction between molecules, ranging from discrete complexes to large architectures. The course will discuss supramolecular systems going from basic molecular recognition (involving single, monovalent interactions), to systems with cooperativity and/or multivalency, and finally to large polyvalent systems. For all subclasses, molecular and biomolecular examples will be discussed as well as materials applications.
Content description		1. Noncovalent interactions, development of supramolecular chemistry (incl. the Excel modeling of thermodynamec equilibria) 2. Synthetic host-guest chemistry I: cation-binding hosts 3. Synthetic host-guest chemistry II: binding of guests in solution 4. Molecular recognition in biological systems, enzyme catalysis 5. Sensor concepts and sensor devices 6. Cooperativity: molecular and biomolecular (e.g. hemoglobin) examples 7. Multivalency: effective molarity concept, cyclization, cell membrane recognition 8. Polyvalent systems I: macromolecular assembly + supramolecular polymers 9. Polyvalent systems II: coordination polymers, MOFs 10. Polyvalent systems III: proteins an protein folding 11. Polyvalent systems IV: virus assembly 12. Polyvalent systems V: DNA + artificial DNA constructs 13. Polyvalent systems VI: layer-by-layer assembly 14. Polyvalent systems VII: supramolecular materials
Prior knowledge		Required: Organic chemistry & Thermodynamics
Course material		- Supplementary handouts (review articles, presentation files) - "Supramolecular Chemistry", J.W. Steed & J.L. Atwood, 2009, 2nd edition, Wiley (required) - "Organic Chemistry", Paula Y. Bruice, 2007, 5th edition, Pearson International Edition/Prentice Hall (or older/newer edition) (chapters and paragraphs on structure of carbohydrates, proteins, and nucleic acids (recommended)

193700010		AMM - Characterization
5 ec	1A	

Lecturer(s)	Prof.dr.ir. J. Huskens, prof.dr.ing. A.J.H.M. Rijnders, dr. P.M. Schön, prof.dr. G.J. Vancso
Objective	To explain and identify the physical and instrumental principles of techniques used for the molecular and continuum (macroscopic) scale characterization of organic and inorganic materials and their application to specific questions. By the end of this course the students are able to estimate specific materials and molecular properties from given examples and problems.
Content description	Materials Characterization refers to the use of techniques to probe into the internal structure and properties of molecules and materials. This course includes various modern, state of the art analytical techniques to characterize structure and properties of advanced materials and molecules. It emphasizes the general applicability to organic and inorganic materials. The central goal is to provide a fundamental understanding of various aspects of molecular and continuum (macroscopic) scale characterization of organic and inorganic materials, which are divided into various problems: 1. Molecular characterization 2. Ensemble characterization - in solution - in solid state 3. Surface / Interface characterization 4. Heterogeneous systems: dispersions, particles
Prior knowledge	Basic knowledge in Physical Chemistry, Organic and Inorganic Chemistry and Materials Science.
Course material	Handouts; review articles; Powerpoint presentations of the lectures. Yang Leng, Materials Characterization John Wiley & Sons, 2008 (recommended, as supporting material, covers only partly the course topics)

193700030		**AMM – Organic Materials Science**
5 ec	**1B**	
Lecturer(s)		Prof.dr. G.J. Vancso
Content description		Organic materials feature enormous variations in their physical properties as a result of the tremendous wealth of the different possible existing molecular structures of carbon basedcompounds. The consequence of this plethora of properties is that function and use of organicmaterials can be tailored by controlling molecular structure virtually at will by using modernsynthetic approaches, allowing one to realize many advanced applications, which belonged to therealm of phantasy just a few decades ago. In this lecture molecular structure-property relationswill be discussed for the different types of (advanced) synthetic and natural (macromolecular)organic materials, including man-made polymers, liquid crystals, carbon allotropes (nanotubes,fullerenes and graphenes), dendrimers, nucleic acids, proteins and polysaccharides.

	Materials selection diagrams will be used to compare organic, inorganic, metallic and other materials,focusing on mechanical properties. Similarities and differences on the basis of molecular/atomicstructures among the different classes of materials will be elucidated. Approaches will be treatedwhich allow materials engineers to quantitatively estimate physical properties based on themolecular structure (by the so-called group contribution techniques). Effects of processing onstructure (texture) and hence on properties will be demonstrated. A description and comparisonof the major classes of the most frequently used industrial polymers for different function will complement this course. This is an advanced level graduate course, thus basic knowledge of organic chemistry, materials science and polymer science taught in the bachelor curriculum is aprerequisite and will be assumed. - Introduction (course overview, keywords of knowledge required, exam expectations,recommended literature) (lecture notes) - Overview of structures of the major classes of organic materials (polymers, liquidcrystals, carbon allotropes (nanotubes, fullerenes and graphenes), dendrimers, nucleicacids, proteins and polysaccharides (lecture notes) - Materials selection diagrams, organic, metallic and ceramic materials contrasts andsimilarities (M.F. Ashby, Materials Selection in Mechanical Design) - Carbon allotropes as molecular building blocks (fullerenes, carbon nanotubes andgraphenes) - Dendrimers and hyperbranched structures - Elastomers, rubber and hydrogels - Liquid crystals as functional materials - Relationships between polymer structure and properties Part I: main chain effects(H.R.Allcock et al., Contemporary Polymer Chemistry, 3rd Ed. Chapter 22) - Relationships between polymer structure and properties Part II: side chain effects (H.R.Allcock et al., Contemporary Polymer Chemistry, 3rd Ed. Chapter 22) - - Group contribution techniques for estimating properties based on molecular structure(D.W. van Krevelen, Properties of Polymers); Calculation examples - Industrial polymers (H. Ulrich, Introduction to Industrial Polymers) - Influence of processing, texture and anisotropy Part I.(I.M.Ward, Editor, Structure and Properties of oriented Polymers) - Influence of processing, texture and anisotropy Part II.(I.M.Ward, Editor, Structure and Properties of oriented Polymers) - Electroactive organic materials - Photonic organic materials (solar cells, light emitting organics, photochromism, photonicband gap materials) - Natural organic engineering materials
Prior knowledge	Chemie & Technologie van Organische Materialen (CTOM, 19135539)
Course material	“Soft condensed matter”, Richard A.L. Jones, ISBN 978-0-19-850590-7

193700040		AMM – Inorganic Materials Science
5 ec	2A	
Lecturer(s)		Dr.ir. G. Koster, prof.dr.ing. A.J.H.M. Rijnders
Objective		The aim is to provide knowledge of fundamental aspects of the structure/composition in relation to the properties and performance of advanced inorganic materials. These are novel materials or modified materials with new or enhanced properties to cope with the increased demands in technological applications. These are, amongst others, electronic applications (dielectrics and ferroelectrics), optical applications (transparant conducting oxides) and materials for energy production and storage (ionic conductors, and mixed electronic/ionic conductors).
Prior knowledge		Required: Chemistry and Technology of Inorganic Materials
Course material		“Understanding solids: the science of materials”, R. Tilley, Wiley 2007 (required)

193700050		AMM – Project Organic Materials
5 ec	2A	
Lecturer(s)		Dr. M.A. Hempenius
Objective		This Lab course aims to broaden the knowledge and skills of students in the areas of polymer synthesis, polymer characterization, and processing. The course illustrates structure-property relations in polymeric materials, i.e. how polymer chain characteristics and composition influence macroscopic properties.
Content description		The following topics are included: 1. Well-defined polymers by Anionic Polymerization. 2. Thin polymer films as separation media. 3. Polymer characterization in solution. 4. Designer surfaces by polymer grafting. 5. Smart materials. 6. Micro / nanofabrication with polymers.
Course material		Manuals describing the various experiments (will be provided)

193700060		AMM - Applications
5 ec	2B	
Lecturer(s)		Prof.dr.ir. R.G.H. Lammertink
Objective		To gain insight in several aspects related to the commercialization of a materials science related technology. Obtain experience with project working, planning and reporting. Search and select patent literature independently. Describe and identify potential customer groups, select from these based on marketing aspects. Construct a simple profit-loss balance

	and budget overview
Content description	Students will work in small groups of 4 to 5 students on a project. Starting point of this project is a patent related to materials science. From this patent the student have to build a business plan. Items that need to be addressed are the IP position, marketing and finances. Each part will be separately treated during presentation. The course will be finalized with a report and an elevator pitch.
Course material	Patent, handouts, reader
Assessment	Presentation, report

193700070		**AMM – Project Inorganic Materials & Molecular S&T**
5 ec	**2B**	
Lecturer(s)		Dr. S.C.S. Lai, dr.ir. G. Koster
Objective		The course is aimed at exposure to a variety of synthesis and characterization techniques by means of two practical projects. The possible projects are embedded in six research groups with different research themes
Prior knowledge		AMM or AMS courses (required)
Assessment		Two reports

193799009		**Internship**
20 ec	**-**	
Contact person		Ing. A. Folkers
Aims		- to perform an assignment applying the principles and methods of Chemical Engineering in a practical situation, - to gain insights into the functioning of a professional organization, - to obtain specific competencies necessary for working in a professional institute or company, - to gain insights about the field of Chemical Engineering
Content description		The internship is an integral part of the Master of Science of Chemical Engineering programme. (Master's students with a preceding HBO-bachelor diploma have an adapted programme without an internship period. If these students wish, the may ask for an internship period as well as an additional course). The internship has to be scheduled in the first or the second year of the master, has to cover at least 13 weeks (20EC) and should be conducted preferably at a company but can also be conducted at a research institute or an university. Students may start the assignment after completing their bachelor Degree. The TNW master programmes offer several opportunities for adding an international dimension to the knowledge and the practical experience of a student. Therefore the internship may be carried out in the Netherlands or

	abroad. We believe a stay abroad is a valuable component of the study; therefore stimulating measures like the Twente Mobility Fund (TMF-fund) and the Erasmus-scholarship are available. The internship is coordinated by the internship coordinator. Orientation for internship has to start half a year prior to national internship and a year prior to international internship. This time is required for actual arrangements of the internship, such as getting an accommodation, visa and all formalities. Application for the internship has to be submitted to the Student Mobility System http://webapps.utwente.nl/srs/en/srsservlet All relevant information, internship posts and all required forms for the internship can be found on the Blackboard organization ‘Internships TNW’. International students should also contact Rik Akse during the arrangement of the internship. (h.a.akse@utwente.nl)
More information	Blackboard Organizations: Internship TNW http://www.tnw.utwente.nl/che/education/internship

201300054 / 55		**Master Thesis**
25 / 20 ec	**-**	
Contact person		dr.ir. B.H.L. Betlem
Description		The individual master assignment is the completion of the master's programme. The main objective of the assignment is that the student learns and proves that (s)he is able to define, perform, complete and reflect a research project at a large degree of independence. The assignment is performed in one of the Chemical Engineering research chairs of the faculty of Science and Technology of the UT under the supervision of a mentor and the responsibility of a Master's Assignment Committee. Conditionally, the assignment can be done (partially) at another external UT-group or an external institute or organization.
Content description		The student has to perform a substantial research or design project that meets scientific criteria. The level of profundity and complexity is defined by the chairman of the MSc.-assignment committee. The student completes the assignment with a written report (the MSc.-thesis) and an oral public presentation.
Assessment		The MSc. project assignment will be assessed with two marks. The first mark covers the quality of the research performance, whereas the second mark covers the other three mentioned objectives, concerning the reporting and general aspects of the research
Codes		201300054 (25 ec): Master Thesis Scientific and Research Aspects (SRA) 201300055 (20 ec): Master Thesis Reporting and General Aspects (RGA)

Elective modules

193737010	Advanced Ceramics
5 ec | -	
Lecturer(s)	Prof.dr. A.J.A. Winnubst
Objective	The aim of the course is to obtain insights in processes, which play a role in the fabrication of inorganic (or ceramic) materials and ceramic coatings. If one has sufficient insight in the several process steps in ceramic fabrication it is possible to make a reproducible material with regard to microstructure and properties.
Content description	Several steps in the fabrication process of ceramic materials are discussed and the importance to understand the effects of processing variables on the evolution of microstructural parameters is emphasized. Basic processes are treated like powder preparation, powder treatments (milling and mixing), forming into a green shape and sintering. Basic phenomena are e.g.: particle size, interaction between particles, nucleation/crystallization, solid state reactions and transport phenomena in solid state systems. The objective in materials process engineering is to find relations between (desired) materials properties and relevant microstructural parameters on one side and to understand which process parameter changes a certain microstructural parameter on the other hand. The basic processes and phenomena, as indicated above, will be treated in lecture notes and tutorials. An important aspect of the course is the in-depth treatment by the student of a specific part of a ceramic fabrication process. This project will be presented by means of a literature essay and a lecture. It is also possible to perform a small practical assignment, treating a specific part of the course. The content of this practical course is determined in consultation with the student.
Course material	Lecture notes

201300049	Advanced Molecular Separations
5 ec | 1B	
Lecturer(s)	Dr.ir. W.M. de Vos, dr.ir. B. Schuur
Objective	At the end of the course the students should: 1. Be able to list relevant industrial (advanced) separations, including those applied in the energy, bulk chemical, fine chemical, and pharmaceutical industries. Understand their working principles, molecular basis of separation and role within larger processes. 2. Be able to make a motivated decision for a separation technology based on the molecular properties of the molecules to be separated. 3. Be able to analyze a separation technology related case, asses the

	technical feasibility of different separation technologies, and develop a separation process. 4. For fluid separations and membrane based separations, be able to calculate mass transfer and thermodynamic properties within a separation process. Be able to design a functional extractant, adsorbant or membrane for a given molecular separation.
Content description	In Advanced Molecular Separations, separation technology is discussed starting from molecular properties up to full scale processes. The focus is on choosing a separation technology for given molecular properties, and the subsequent molecular design of more advanced separation technologies. For two separation technologies, fluid separations and membrane technology, the molecular design and separation process are treated in much greater detail, including a discussion on useful models to describe thermodynamics and mass transfer. The course will include two tests, one on fluid separations and one on barrier separations, but will also include two assignments on selecting the right separation technology for a given separation case
Course material	Reader and Henley, Seader and Roper: “Separation Process Principles, International Student Version, Third edition”. ISBN: 9780470646113 (required)

201200119		**Batteries, Fuel Cells & Electrolysers**
5 ec	**1B**	
Lecturer(s)		Prof.dr. H.J.M. Bouwmeester, prof.dr.ir. D.C. Nijmeijer
Content description		1. Introduction, basic principles and theory 2. Thermodynamics of electrochemical cells, losses and efficiency 3. Electrolyte membranes, membrane electrode assemblies 4. Electrode kinetics 5. Different types of batteries and fuel cells; SOFC, SAFC, PEMFC, DMFC, BioFC, AFC, primary and secondary batteries, etc. 6. Miniaturization and other recent trends 7. Societal relevance and acceptance
Course materials		Lecture notes “Fuel cell handbook”, US Department of Energy, 2004

193740050		**Biochemistry**
5 ec	**2B**	
Lecturer(s)		Dr. A.A. Poot
Objective		To obtain basic knowledge of cellular processes.
Content description		During this course basic knowledge is provided concerning compounds and processes in living cells. Topics include cell structure, biomembranes, amino acids, proteins and enzymes, the role of ATP, glycolysis and oxidative

	metabolism, genetic information, gene regulation, recombinant DNA technology, tissues and cancer.
Prior knowledge	Desired: Chemistry and biology (VWO-level)
Instruction mode	Self-study
Course material	“Essential Cell Biology”, Alberts et al., Garland Publishers, New York, 4e edition 2013, paperback ISBN 978-0-8153-4455-1 (recommended)

201400143		**Bioinspired Molecular Engineering**
5 ec	**-**	
Lecturer(s)		Dr. P. Jonkheijm
Objective		Surface science for bio-applications. Surface modification strategies; stimuli-responsive surfaces; bioactive surfaces; micro- and nanopatterning of surfaces; cell repellant an d adhesive surfaces; cell-material interfaces
Content description		It is generally accepted that synthetic and semi-synthetic materials are an asset for, among others, medical doctors trying to improve the quality of life of their patients. This can for example be achieved by replacing damaged organs or tissues with artificial hips, knees, heart valves, blood vessels and so forth. To successfully do this, however, the clinicians do need a solid understanding of how the artificial materials interact with the body of the patient and which biological feedback loops may be triggered or altered by, for example, implantation. Biomimetic materials chemistry is essentially founded on the recognition that in many aspects Nature is superior to human technology. It is much more clever if you wish. Because the first contact between tissue and material is always at the surface, the surface of a material needs very special attention from scientists and engineers as well as from clinicians. We will cover physical and chemical strategies for generating a specifically organized surface. Various surface architectures (supramolecular, polymer, hydrogels, etc) and properties (stimuli-responsive, gradient, biofouling, sensors, topography, patterning, etc) will be discussed. Model substrates for protein chips, cell adhesion, cell sheet production, cell mechanics, and electrode-tissue interaction will be discussed.

201400283		Biomedical Materials Engineering
5 ec	1B	
Lecturer(s)		Dr. A.A. Poot, prof.dr. D.W. Grijpma
Objective		To understand the basic principles of polymer processing, biomaterial surface modification and tissue-biomaterial interactions in regenerative medicine. To learn how to draw up and defend a research proposal.
Content description		This course deals with the basic principles of tissue-biomaterial interactions, surface modification of biomaterials and polymer processing for regenerative medicine. Moreover, groups of 3-4 students draw up a research proposal that has to be defended during a plenary session.

201400284		Biomedical membranes and (bio) artificial organs
5 ec	2A	
Lecturer(s)		Dr. D. Stamatialis
Objective		The course aims to introduce to the students important biomedical membrane applications. Specific attention is given to the translational aspects and the introduction of the technology to the clinic.
Content description		The course covers biomedical applications where the artificial membrane plays a crucial role. Main topics are: membrane preparation and characterization, drug delivery, blood purification-dialysis, blood oxygenation, bio-artificial kidney, bio-artificial pancreas, bio-artificial liver and tissue engineering. The course combines theory, assignments as well as experiments.
Course material		Basic Principles of Membrane Technology, Second edition by M. Mulder, Kluwer Academic publischers, ISBN 0-7923-4247-x (required) Membranes for life sciences, Peinemann, K. V., Nunes S, Ed. Wiley, ISBN: 978-3-527-31480-5 (2008) (required)
Assessment		Oral exam, paper, presentation.

xxxxxxxxx		Capita Selecta (MME track)
5 ec	-	
Description		All research groups offer 5 EC Capita Selecta (C.S.) modules, that you can take as an elective in your MSc program. For detailed information on these, please contact the group leader for more information on the format and content. Underneath is the list of available C.S. courses (with contact persons)
Available courses		**C.S. Biomaterials Science and Technology** (201300052) Prof.dr. J.D. de Bruijn, prof.dr. D.W. Grijpma, dr. A.A. Poot, dr. D. Stamatialis **C.S. Biomedical Chemistry** (193742000)

	Dr.ir. J.M.J. Paulusse, prof.dr. J.F.J. Engbersen **C.S. Biomolecular Nanotechnology** (193700080) Prof.dr. J.J.L.M. Cornelissen **C.S. Inorganic Materials Science** (193770000) Prof.dr.ir. J.E. ten Elshof, prof.dr.ing. A.J.H.M. Rijnders **C.S. MTP: Macromolecular Nanofabrication** (193730070) Dr. M.A. Hempenius, dr. P.M. Schön, prof.dr. G.J. Vancso **C.S. Molecular Nanofabrication** (193775000) Prof.dr.ir. J. Huskens **C.S. Catalytic Processes and Materials** (193765000) Prof.dr.ir. L. Lefferts, prof.dr. K. Seshan **C.S. Inorganic Membranes** (193737000) Dr.ir. N.E. Benes, prof.dr. H.J.M. Bouwmeester, prof.dr.ir. A. Nijmeijer, prof.dr. A.J.A. Winnubst **C.S. Membrane Technology** (193735000) Dr.ir. A.J.B. Kemperman, prof.dr.ir. D.C. Nijmeijer, dr.ir. W.M. de Vos **C.S. Mesoscale Chemical Systems** (193780000) Prof.dr. J.G.E. Gardeniers **C.S. Soft Matter, Fluidics and Interfaces** (201000218) Prof.dr.ir. R.G.H. Lammertink

193765020		**Catalysis for Sustainable Technologies**
5 ec	**1B**	
Lecturer(s)		Prof.dr. K. Seshan
Objective		Understanding the key aspects environmentally friendly catalytic process using specific examples relevant to daily life.
Content description		Introduction. Legislation, specific environmental problems and solutions. Course description: The central theme of the course is the use of catalysis to solve current environmental problems. Legislation regarding environmental pollution is getting more stringent every day. Catalysis, by minimizing pollution, provides two ways to improve quality of our environment. These are:1: development of alternative cleaner / greener processes 2: cleaning up emissions from currant processes. In this course, the role of catalysis in both these situations will be discussed especially with the use of examples that cause environmental pollution. For the purpose of evaluation students are required to make a literature study on the topic assigned to them, make a report and present a colloquium.
Prior knowledge		Required: Kinetics and Catalysis
Course material		Lecture notes, presentation sheets

193765030		Catalysis in the Process Industry
5 ec	2B	
Lecturer(s)		Prof.dr. K. Seshan, prof.dr.ir. L. Lefferts
Objective		To understand factors involved in applying catalysis under industrial conditions.
Content description		Almost all the commercial petroleum/petrochemical processes for the generation of fuels and chemicals involve the use of a catalyst. Aspects of catalysis that are critical for application in such industrial processes will be discussed in this course. Typical examples of catalytic processes such as cracking, reforming, hydro-treating, alkylation and chemical processes as epoxidation, ammonia synthesis, oxy-chlorination will be taken up. Students are required to carry out a literature study on a topic provided and present the results in a colloquium and a report. Lectures will also include presentation by experts from industry with specific attention to the role of catalysis in the chemicals and fuels production.
Prior knowledge		Required: Kinetics and Catalysis
Course material		Lecture notes, presentation sheets, reading material

193770090		Chemistry of Inorganic Materials and Nanostructures
5 ec	-	
Lecturer(s)		Prof.dr.ir. J.E. ten Elshof
Objective		Chemistry of advanced functional inorganic materials
Content description		The design and synthesis of advanced functional materials by chemical processing methods requires a thorough understanding of the basic reaction mechanisms and physical phenomena that play a role in the sequence of steps that lead from starting molecular precursors via nanoparticles to the final functional solid. This course provides an introduction into the chemistry of inorganic materials, the most common chemical synthesis methods, and their deposition into low-dimensional nanostructures, thin films and micropatterns. Topics that are discussed in the course include inorganic molecules; structural solid state chemistry; physical chemistry of inorganic surfaces; nucleation and growth of nanoparticles; morphogenesis of particles with fractal-like structure; synthesis of inorganic materials; soft chemistry; thin films; low-dimensional nanostructures; soft lithography; sintering.
Prior knowledge		Required: Inorganic Chemistry (191330012) Desired: Colloids and Interfaces (193735060)
Assessment		Oral examination
Course material		Handouts Recommended books: “The Inorganic Chemistry of Materials”, P.J. van der Put, Plenum Press, New

	York, 1998 (recommended). “Nanostructures & Nanomaterials”, G. Cao, Imperial College Press, London, 2004 (recommended) “Basic Solid State Chemistry”, A.R. West, 2nd edition, Wiley, Chichester, 1999 (recommended). “Sol-Gel”, J.D. Wright, N.A.J.M. Sommerdijk, CRC Press, Boca Raton, 2000 (recommended).

193735060		**Colloids and Interfaces**
5 ec	**1A**	
Lecturer(s)		Prof.dr.ir. R.G.H. Lammertink
Objective		Learning objectives of this course include: - Gain insight in important interfacial aspects including interfacial energy and surface potential. - Be able to explain and describe different interfacial phenomena (wetting, adsorption, colloidal stability). - Critically evaluate scientific literature on interfacial phenomena.
Content description		Description of interfaces and surfaces. All kinds of interfaces between different phases (gas, liquid, solid) are treated. Thermodynamic descriptions of these interfaces and adsorption onto them are deduced. Several techniques for characterizing interfaces are discussed. During contact hours, the contents of the book will be presented and discussed. For each topic, a case assignment will be offered. Learning objectives of this course include: Gain insight in important interfacial aspects. Be able to explain and describe different interfacial phenomena (wetting, adsorption, colloidal stability). Critically evaluate scientific literature on interfacial phenomena.
Course material		Interfacial Science An Introduction, G.T. Barnes and I.R. Gentle (required)

193799700		**Contract research (for study trip)**
5.0 ec	**-**	
Contact person		Dr.ir. B.H.L. Betlem
Objective		The objective is to conduct a some research commissioned by an internal or external client. The project must be performed to the satisfaction of both the client and the supervisor. Both of them will evaluate the project and report.
Content description		This Contract Research Assignment is conducted by groups of 2 students and is for the financial support of the international study tour. Projects are coming from internal and external customers. The assignment is coached by a staff member selected on the basis of the subject of the assignment. He/she coaches and helps the students but also grades the final result which is almost always a report for the customer.

193740010		Controlled Drug and Gene Delivery
5 ec	**1A**	
Lecturer(s)		J.M. Metselaar
Content description		Controlled drug delivery technology represents one of the emerging and challenging frontier areas in the development of modern medication and pharmaceuticals. Controlled drug delivery systems aim to achieve more effective therapies which eliminates the potential for both under- and over-dosing originating from uncontrolled drug release and avoid the need for frequent dosing and target the drugs better to a specified area, minimizing drug side effects. Targeted drug delivery can be accomplished by the introduction of ligands (carbohydrates, hormones, and peptides) or antibodies to the drug delivery system in such a way that it binds preferentially to malignant cells that are uniquely expressing certain receptors at the cell surface. In gene therapy, a genetic disorder or chronic disease is treated by delivering DNA or RNA to the targeted cells, inducing or suppressing a specific genetic function like new immune activity, or the development of enzymes that destroy viral or cancerous genetic material within cells. The ideal drug or gene delivery system should be nontoxic, biocompatible, safe from accidental release, simple to administer, easy to fabricate and sterilise, and should have efficient drug or gene targeting specificity. Delivery systems based on polymeric backbones can fulfill the majority of these requirements and have come to the centre stage of biomaterials research in recent years. This course gives a review of the recent advances and directions of future developments in controlled release technology. Topics included are: fundamental principles of controlled drug and gene delivery and their pharmaceutical applications in various delivery routes (oral, pulmonary, nasal, oculary, brain, etc.); delivery from biodegradable polymeric systems (nanoparticles, hydrogels, microspheres, dendrimers, etc.), microstents and nanodevices; delivery in tissue engineering.
Course material		Handouts

191156500		Elastomeric Technology
5 ec	**2A+2B**	
Lecturer(s)		Prof.dr. A. Blume, dr. W.K. Dierkes
Objective		Define performance criteria for rubber (as part of the broader polymer technology) articles and translate these into the design and production of compounds and articles with the specific visco-elastic or rubber-elastic material behaviour of elastomers.
Content description		Elastomer or Rubber Technology represents a sub-group of the wider field of polymer technology. It covers about 15% of the total polymer turnover. Polymer-technology originated from rubber-technology, but rubbers have kept their own identity because of their unique combination of resilience and form stability after extremely large deformations, commonly designated as "rubber-elasticity".

	Elastomeric articles always are there to perform a function, wherein the rubber-elastic properties are the key factor: e.g. a car-tire translates all car-drivers interventions into the car-road contact: accelerating, breaking, cornering, etc. In this functional performance, the design of the article, the composition of the elastomeric material - commonly prepared for the purpose and called "compounding" - and the manufacturing technique all come together and jointly determine the end-result. In this introductory course the structural characteristics and properties of elastomers are covered, as well as the basic principles of compounding, processing and vulcanization, all illustrated with representative examples of rubber applications. The course includes a 5 days laboratory training into rubber compounding, vulcanization and characterization of mechanical properties, mainly to illustrate and visualize the main processing and performance tests in use in the rubber world, as they are different from thermoplastic polymers.
Prior knowledge	Some basic knowledge of polymers
Course material	- "Rubber Compounding", B. Rodgers (ed.), Marcel Dekker Inc., New York, Basel (2004) - Lecture notes: "Elastomeric Technology" 115650, nr. 799

193770070		**Imperfections**
5 ec	**-**	
Lecturer(s)		Dr.ir. G. Koster
Content description		Study of a topic in solid state chemistry concerning a deviation from perfect crystallinity. For example, at a crystal surface, atoms are not similarly coordinated as the bulk atoms, point defects, color centers, quasi crystals etc. What are the consequences for the properties? Can defects be synthesized in a controlled manner and thereby the properties of a material. The course will be given in the form of informal lectures and discussion sessions. The students will give some lectures. The final grade is determined by homework and the lectures. Students are requested to contact the professor prior to the start of the course.
Prior knowledge		AMS courses
Course material		- Defects in Solids, Richard J. D. Tilley, ISBN: 9780470077948, Copyright © 2008 John Wiley & Sons, Inc. (required) - Inorganic Chemistry, Shriver and Atkins, 4th edition (recommended)

193770030		**Lab Course Advanced Materials**
5 ec	**-**	
Lecturer(s)		Prof.dr.ir. J.E. ten Elshof, dr.ir. G. Koster, prof.dr.ing. A.J.H.M. Rijnders
Objective		Train practical skills in synthesis and characterization of modern functional

	inorganic materials.
Content description	Functional inorganic materials (especially complex metal oxides) are used in almost every modern device. Inorganic materials exhibit properties that are mostly difficult or impossible to achieve with other materials, so their presence is often crucial for the functionality of a device. Nanoelectronics, superconductors, magnetic and many electrical materials are just some examples. The way in which inorganic components are made is usually decisive for the final crystallographic structure, microstructure and functional properties of the material. This lab course is intended as a hands-on introduction to the field of advanced functional inorganic materials, their synthesis and characterization. Students get an individual assignment depending on his/her interests. The assignment may focus on the deposition of thin films or nanostructures by advanced physical or chemical deposition methods, the characterization of crystallographic structure by X-ray diffraction, the characterization of microstructure by atomic force microscopy or electron microscopy, or a combination of these.
Note	This is a practical course.

201400290		**Labcourse Chemistry for Biomedical Applications**
5 ec	**1A**	
Lecturer(s)		Prof.dr. D.W. Grijpma, dr.ir. J.M.J. Paulusse
Objective		In this laboratory course the students will acquire experimental skills related to polymer synthesis and characterization, as well as the processing of polymers into medical devices. The students will be able to analyse, discuss and present their results in a written report.
Content description		In medical implants and -devices, polymer-based biomaterials play an essential role. This laboratory course covers a broad range of experiments in which the student prepares his/her own medical implant or device, and assesses its functionality. Research topics that are treated during this course include: - Biodegradable polymer-based materials in implant devices and drug delivery - Ring-opening polymerization and network formation by photo-polymerization - Advanced (composite) biomaterials and microstructures - Well-defined polymers and nanoparticles
Note		Students can register for this course via dr. ir. J. Paulusse (j.m.j.paulusse@utwente.nl)
Course material		Handouts, course guide

201200117 5 ec | 1A	**Membranes for Gas Separation**
Lecturer(s)	Prof.dr. H.J.M. Bouwmeester, prof.dr.ir. D.C. Nijmeijer
Objective	Understanding of basic principles of gas separation and gas transport in membranes.
Content description	1. Introduction, basic principles and theory 2. Polymer membranes 3. Metallic membranes 4. Carbon, zeolite and micro-porous (sol-gel derived) ceramic membranes 5. Mixed conducting oxide membranes 6. Competitive technologies for gas separation and treatment (cryogenic distillation, pressure swing adsorption, absorption methods etc.)
Instructional modes	Lectures and practicals
Course material	Lecture notes, slides, literature (will be provided through BB) “Materials Science of Membranes”, Y. Yampolskii, I. Pinnau, B.D. Freeman, John Wiley & Sons, Ltd. 2006 (recommended, as background information) “Membrane Technology and Applications”, R.W. Baker, John Wiley and Sons Ltd., 2004. (recommended, as background information)

193740040 5 ec | -	**Organic chemistry of polymers**
Lecturer(s)	Prof.dr. P.J. Dijkstra
Content description	A study towards the main polymerization processes; step-, chain-, and ring-opening polymerization. Structure-properties relationships of natural and synthetic polymers
Prior knowledge	Required: General and (bio)organic chemistry
Instructional mode	Self-study
Course material	“Organic chemistry”, Paula Y. Bruice, ISBN 978-0321663139

193775020		Physical Organic Chemistry
5 ec	**2A**	
Lecturer(s)		Dr. P. Jonkheijm, prof. dr. ir. J. Huskens
Objective		Making correlations between stable organic structures and reactive intermediates enables students to develop reaction mechanisms using concepts of structure and bonding. The students will learn the ability to anticipate and design organic chemistry experiments and decipher their mechanism using concepts of kinetics and dynamics. Several examples from organometallic chemistry, bio-organic chemistry and enzymology are used to highlight the utility of the techniques in different fields. The students will advance their analysis of electronic structure theory by getting acquinted with notions of quantum mechanics. The students will apply these notions to the analysis of pericyclic reactions, photochemistry and electronic organic materials.
Prior knowledge		Required: Structure and reactivity (191300041); Organic chemistry (191320013)
Course material		"Modern physical organic chemistry", Eric V. Anslyn/ Dennis A. Dougherty, University Science Books, Sausalito, California, 2006 (required)
Note		This course is offered in combination with C.S. Molecular Nanofabrication (193775000, prof. dr. ir. J. Huskens)

201000308		Photocatalysis Engineering
5 ec	**2B**	
Lecturer(s)		Prof. dr. G. Mul, prof. dr. R. Lammertink
Objective		Gaining fundamental and practical knowledge of the factors which determine the performance of photocatalytically active materials and reactors, as well as understanding design criteria for solar to fuel devices.
Content description		Introduction to use of semiconductors in photocatalytic reactions, including Z-scheme configurations, and effects of (supported) catalyst properties (surface area, crystallinity, colloidal behaviour, and interfaces) on performance. Engineering guidelines of photocatalytic processes: we will discuss the effect of various reaction parameters, including light intensity, temperature, slurry density, and photoreactor design on achievable rates and efficiency. Methods to characterize photocatalytic performance, including some photocatalysis experiments in the PCS or SFI laboratories. Kinetics will be discussed on the basis of practical examples in microreactors, including several matlab tutorials on modelling of mass and light transfer. Design criteria of solar to fuel devices, including assignment to design your own!
Prior knowledge		BSc in Chemistry, Chemical Engineering, Advanced technology, or Physics
Course material		"Photocatalytic Reaction Engineering", Hugo de Lasa, Benito Serrano, Miguel Salaices, http://link.springer.com/book/10.1007%2F0-387-27591-6), Matlab cases, and papers from the current literature

More info	Please contact Martina Overdulve (m.m.j.overdulve@utwente.nl) and register as “bijvakker” when not a student of the University of Twente. Otherwise through Blackboard.

193730060		Polymer physics
5 ec	-	
Lecturer(s)		Prof.dr. G.J. Vancso
Content description		A coherent introduction at the graduate student level is offered into the properties and behavior of soft matter. The treatment follows the book “Soft condensed matter” of R.A.L. Jones. The content of the book will be discussed in small groups, allowing students to read/prepare and ask questions chapter by chapter. Focus is on a general overview of soft matter, phase transitions, colloidal dispersions, polymer gelation, molecular order, supramolecular self assembly in polymers, and soft matter in nature.
Course materials		“Soft condensed matter”, Richard A.L. Jones, ISBN 978-0-19-850590-7

193730040		Polymers & Materials Science Practice
3 ec	1A	
Lecturer(s)		Dr. M.A. Hempenius
Objective		This laboratory course is an elective course where students can deepen their knowledge and skills in selected areas in polymer chemistry (synthesis, molecular characterization) and materials science.
Content description		The topic of this Lab Course is "Controlled Polymerizations", we will perform a living/controlled ATRP polymerization of methyl methacrylate using a tetrafunctional initiator and aim to form a well-defined four arm star polymer. Then, a second block will be attached to create a core-shell star block copolymer. These materials are of interest in the biomedical field for imaging, drug loading, etc. During polymer synthesis, a glove box and vacuum lines will be used. Techniques that we use for characterization of these polymer architectures include 1H NMR spectroscopy, Gel Permeation Chromatography (GPC), and Differential Scanning Calorimetry (DSC)
Assessment		Reports

193720050		Theory of Phase Equilibria
5 ec	-	
Lecturer(s)		Dr.ir. M.A. van der Hoef
Content description		The first part of this course consists of a recapitulation of elementary thermodynamics from a more formal viewpoint by using state functions, rather than from processes, as is common in most undergraduate courses. This formalism will then be applied to a description of phase-equilibria between two or more phases of single component systems. This is followed by a description of phase equilibria in two- and three-component systems,

	where the solutions are considered to be ideal. Finally, non-idealicity is introduced via excess functions and activity models. The most important application is found in the calculation of the P-x,y diagram of a binary system, starting from well-known excess state functions such as the Peng-Robinson and the RKS equation of state. This calculation will require some code development. This course is highly suitable for self study, where assistance from the lecturer can be obtained on an individual basis, preferably by appointment. In any case it is requested to get into touch with the lecturer before commencing. In the case of self-study, the course can be done the whole year round. If there is sufficient interest, a limited set of lectures will be given, in principle in the third term.

193735010		**Thermodynamics and Flowsheeting**
5 ec	**1B**	
Lecturer(s)		Dr.ir. A.G.J. van der Ham
Objective		Flowsheeting is the use of computer aids to perform steady-state and dynamic heat and mass balancing for chemical processes. Important aspect in this expertise are property set selection, flowsheet analysis and unit operation selection and specification. This course deals with the principles of steady-state flowsheeting, the practical use of modern flowsheeting software and the advantages, limits and pitfalls of these programs. At the end of the course we expect students to be able to work with the flowsheeting tools available. A Thermodynamic correct description of the different phase equilibria is critical for a adequate description of the process. The course is compulsory for the Process Plant Design Assignment (19379001) where this knowledge will be applied to simulate the processes designed,
Content description		The theory is discussed in six lectures, dealing with topics as - Flowsheet analysis to obtain the best calculation sequence, - Models of unit operations available in the databank (model equations, applicability, specifications, etc) - Models to describe the thermodynamic and physical data of pure components but also of mixtures, followed property method selection, - Convergence methods and accelerators, etc. Parallel to the lectures, 5 workshops are scheduled in which the students learn to work with an industrial flowsheeter (UniSim). The UniSim manual with examples is used for this. After a short test the students can start with the final assignment. The final assignment is for groups of two students and consists of three parts: - Analysis of a flowsheet - Simulation of an industrial process based on a process description - Simulation of a separation problem with special focus on the property

	method selection. The project in this way combines simulation skills with design decisions and specifications. The group has to submit a report discussing their simulation, assumptions, specifications and results. They also need to submit their UniSim files. The final mark is based on the report, the simulations and an oral group exam.
Note	This course is only for students, which are not in the CPE track of ChE.
Course material	"Product and Process Design Principles: Synthesis, Analyses and Design", Seider, Seader, Lewin and Widagdo, 3rd edition, 2009 (recommended)
Assessment	Group assignment with oral examination.

191141420		**Transport in Turbulent Chemically Reacting Flows**
3.6 ec	**2A**	
Lecturer(s)		Dr.ir. J.B.W. Kok
Objective		After the course, the student is able to... - explain / describe numerical modeling approaches of transport in turbulent flows - apply these modeling approaches in a commercially available CFD code - describe and analyse the behavior of chemical reaction mechanics with many elementary reactions - describe and analyse the modeling of a chemical reaction in a turbulent environment - solve numerically turbulent transport problems in process or power generation industry
Content description		The course targets the student to know about numerical modelling approaches of transport in turbulent flows, and how to use them in a commercially available CFD code. The student will know about, and how to analyse, turbulent flows with chemical reactions by means of models and numerical simulation. The student will be able to handle modeling off chemical reaction described by mechanisms with many elementary reactions. He will know how use and understand turbulent flow models in a RaNS and LES approach.. This knowledge will enable the student to solve numerically turbulent transport problems in for example the process industry or power generation industry. The course treats the transport in the turbulent flow of gaseous fluids composed of multiple species, by means of diffusion, convection or chemical reaction. Turbulence has a large effect on both convective transport and chemical reaction. The course intends to give an overview of the major processes, and a description by means of transport equations is presented. Numerical tools (Computational Fluid Dynamics) are used for product optimization and analysis. In the course several assignments in the use of numerical models for chemical reaction, turbulent convection and mixing and combustion will be given. The course will be finalized by means of a computer assignment using the CFD package CFX Ansys. A practical case with application on a combustion problem will be worked out. The marking

	will be done on basis of the assignment reports and an oral exam.
Prior knowledge	Knowledge of elementary fluid mechanics at a bachelor level is required. Experience with CFD is beneficial but not required.
Course material	- "Theoretical and Numerical Combustion", 3rd edition, Th. Poinsot and D. Veynante, 2011, ISBN 978-2-7466-3990-4 (available in hard copy and in e-book) (required) - "New developments in Combustion Research", Carey, W.J., Nova Science Publishers, NY, 2006, ISBN 1-59454-826-9. (recommended) - "Combustion Physics", C.K. Law, Cambridge University Press, 2006, ISBN 978-0521-187052-8. (recommended)