PŘÍLOHA P4a k závěrečné zprávě o řešení rozvojového projektu: Internacionalizace studijních programů VŠCHT Praha

Internacionalizovaný navazující magisterský studijní program

Chemical and Process Engineering

Fakulty chemicko-inženýrské

Studijnímu programu byl přiřazen název ***Chemical and Process Engineering*** (CPE), který vyjadřuje jeho základní obsah a koncepci, tj. zaměření na kombinaci chemicko-inženýrsky a procesně-inženýrskyorientovaného vzdělání.

Studijní program je koncipován jako navazující magisterský v trvání dvou roků. Navržený studijní program je plně realizován v kreditním systému kompatibilním se studijními programy strukturovaného studia na VŠCHT Praha, student musí v průběhu studia získat celkem 120 kreditů (60 kreditů za ročník).

Studijní program Chemical and Process Engineering navazuje na základy z bakalářského stupně vzdělání, přednostně ve studijním programu *Process Engineering and Management* a získané znalosti prohlubuje a rozšiřuje o další poznatky nezbytné pro procesně-inženýrské vzdělání, tj. o znalosti procesů sdílení tepla a hmoty, problematiky spolehlivosti a bezpečnosti procesů, informačních a databázových systémů, reaktorového inženýrství, měřicí techniky a matematických disciplin. Bloky povinně volitelných předmětů umožňují volitelně zaměřit znalosti studentů směrem k chemicko-inženýrským disciplinám nebo k disciplinám z oblasti procesního a systémového inženýrství. Studium je zakončeno vypracováním diplomové práce, její obhajobou a státní závěrečnou zkouškou.

Navržený studijní program využívá pouze anglických verzí studijních předmětů obsažených ve studijních plánech strukturovaného studia na VŠCHT Praha, převážně pak ve studijních programech Fakulty chemicko-inženýrské. Nejsou zaváděny nové předměty a nedochází tedy ke zvýšení celkového počtu předmětů vyučovaných na VŠCHT Praha.

Tato skutečnost též nabízí studentům standardních (v českém jazyce vyučovaných) studijních programů možnost, pokud to umožní volná kapacita anglicky vyučovaného programu, absolvovat některé vybrané předměty v anglickém jazyce s tím, že jim budou takto získané kredity uznány. Vzhledem k možnosti, že tato nabídka se setká se značnou odezvou, bude případně nutno stanovit kritéria pro umožnění takové částečné účasti na anglicky vedené výuce (např. na základě studijního prospěchu a prokazatelné znalosti anglického jazyka).

Vzhledem k předpokládanému počtu studentů, resp. zájemců o studium, který je pro počáteční stadium implementace navrhovaného programu předpokládán na úrovni cca 25 posluchačů, tj. v rozsahu jedné studijní skupiny,

byl studijní program od počátku uvažován jako jednooborový s tím, že stupeň volitelnosti předmětů bude, v porovnání se studijními programy strukturovaného studia na VŠCHT Praha, omezen na rozumně únosnou míru.

V každém semestru připadá určitý počet kreditů na volitelné předměty (za celou dobu studia 15-20 kreditů). Předpokládáme, že studenti si budou volitelné předměty vybírat z nabídky celé VŠCHT Praha a že jim bude umožněno absolvovat výuku těchto předmětů i v českém jazyce.

Podmínky pro přijímání uchazečů ke studiu ve studijním programu Chemical and Process Engineering budou v zásadě shodné s podmínkami pro přijímání uchazečů do ostatních navazujících magisterských studijních programů akreditovaných na VŠCHT Praha. Vzhledem k důležitosti dobré předběžné znalosti anglického jazyka pro účast na výuce a pro absolvování studijního programu, bude jako jedno z kritérií pro přijetí ke studiu uvažován prokazatelná znalost anglického jazyka.

Jako učební pomůcky budou studentům doporučovány především anglicky psané učebnice, standardně užívané pro výuku v anglicky hovořících zemích, resp. v dalších evropských zemích (např. Holandsko, Dánsko, Belgie, Švédsko...). Vytváření vlastních učebních pomůcek bude omezeno především na podpůrné materiály (řešení příkladů a úloh ...) prezentované na www stránkách ústavů vyučujících jednotlivé předměty.

Návrh studijního programu "Chemical and Process Engineering" vyučovaného v anglickém jazyce

Magister Study Programme:

Chemical and Process Engineering

Study Branch: **Chemical and Process Engineering**

Programme Objectives:

The programme is designed to prepare the graduates provided with thorough knowledge combining together chemical-engineering and process engineering. Specific chemical engineering courses (heat and mass transfer, reactor engineering, fluid mechanics, engineering thermodynamics), combined with the process engineering subjects (process design, mathematical optimisation, process modelling, measurement engineering) and applied computer science will form a wide base of practically applicable knowledge. The graduates will be able to solve technical, engineering and process control problems. The programme also enables the student building-up strong knowledge of professional English nomenclature.

Description of the Programme:

The first year extends students' knowledge of the fundamentals of chemical and process engineering disciplines and builds on the disciplines that that form theoretical core of the discipline. Students also gain more practically oriented knowledge (safety/reliability engineering, product engineering, bioengineering). The system of blocks of semi-elective courses enables students to direct their professional to demanded area (chemical engineering, process engineering).

Professional Orientation:

The graduates of the programme can get jobs in diverse production facilities, preferably related to chemical, food, pharmaceutical or biotechnology production. They can also find jobs in research and development institutions. Their good knowledge of applied computer science and computer application skills can be exploited in any job.

Návrh
studijních plánů jednotlivých ročníků
navazujícího magisterského studijního programu

CHEMICAL AND PROCESS ENGINEERING

vyučovaného v anglickém jazyce

Fakulty chemicko-inženýrské
Vysoké školy chemicko-technologické v Praze

Study Year: 1

Winter Semester (1)

Required Courses	Weekly load			Assessment	Credits
	L	S	Labs		
Mathemat. Mod. of Processes	2	2	0	C,Ex	5
Systems of ODEs	2	1	1	C,Ex	5
Fluid Mech. and Heat Transf. I	2	2	0	C,Ex	5
Semestral Project	0	3	0	G	3
Totals:	6	8	1		**18**

Semi-elective Courses	Weekly load			Assessment	Credits
	L	S	Labs		
Option I:					
Chemical Engng. Thermodyn.	1	2	0	C,Ex	4
Unit Operations III	2	2	0	C,Ex	5
Measuring and Control Engng.	2	0	2	C,Ex	4
Option II:					
Enterprise Process Managem.	2	1	0	C,Ex	4
Optimization of Engng. Proc.	2	2	0	C,Ex	5
Software for Chem. Engng.	2	2	0	C,Ex	5
Totals:					**8/9**

Students choose one course listed under Option I and one course listed under Option II.

Elective Courses for the 1st Semester*					
Total:					**3/4**

*Student may choose any course open for the 1st semester at any faculty of the ICTP. The elective courses can possibly be completed in the Czech language.

Summer Semester (2)

Required Courses	Weekly load			Assessment	Credits
	L	S	Labs		
Mass Transfer Processes	2	2	0	C,Ex	5
Process and Systems Engineering	2	2	0	C,Ex	5
Specialised laboratory	0	0	4	Gr	4
Totals:	4	4	4		**14**

Semi-elective Courses	Weekly load			Assessment	Credits
	L	S	Labs		
Option I:					
Methods of Applied Mathematics	2	0	0	Ex	3
Partial Differential Equations	2	1	0	C,Ex	4
Option II:					
Engng. Methods in Biol. Processes	2	1	0	C,Ex	4
Product Engineering	2	1	0	C,Ex	4
Totals:					**7/8**

Students choose either all courses listed under Option I or all courses listed under Option II.

Elective Courses for the 2nd Semester*					
Total:					**8/9**

*Student may choose any course open for the 2nd semester at any faculty of the ICTP. The elective courses can possibly be completed in the Czech language.

Study Year: 2

Winter Semester (3)

Required Courses	Weekly load			Assessment	Credits
	L	S	Labs		
Reactor and Bioreactor Engng.	4	2	0	C,Ex	8
Process Project	0	4	0	Gr	4
Specialised Laboratory	0	0	5	Gr	5
Totals:	4	6	5		**17**

Semi-elective Courses	Weekly load			Assessment	Credits
	L	S	Labs		
Option I:					
Process Safety and Reliability	2	1	0	C,Ex	4
Information Sources	2	2	0	C,Ex	5
Option II:					
Information and Database Syst.	2	2	0	C,Ex	5
Comp. Aided Simul. of Proc.	2	0	2	Ex	4
Totals:					**9/9**

Students choose either all courses listed under Option I or all Courses listed under Option II.

Elective Courses for the 3rd Semester*					
Total:					**4/4**

*Student may choose any Course open for the 3rd semester at any faculty of the ICTP. The Facultative Courses can possibly be completed in the Czech language.

Summer Semester (4)

Required Courses	Weekly load			Assessment	Credits
	L	S	Labs		
Diploma Thesis Seminar	0	3	0	Gr	3
Diploma Thesis	0	0	27		27
Totals:	0	3	27		**30**

Sylaby předmětů zahrnutých v návrhu bakalářského studijního programu

Chemical and Process Engineering

Subject Title:	**Mathematical Modelling of Processes**	Number	445xxx
Semester:	M1		
Weekly Load and Assessment:	2/2/0 Ex		
Credit:	5		
Language:	Czech, English		
Prerequisities:	Chemical Engineering		
Course provider:	Department of Computing and Control Engineering		

Module Content:

1. The idea of a model and modelling. Modelling postulates.
2. Modelling methods. Basic terms of continuum mechanics.
3. Heat and mass transfer equations.
4. Hydrodynamics models of flow and their classification. Dynamic characteristics of ideal mixing flow and plug-flow models
5. Models of the ideal mixing tank-in series with and without back-flow
6. Axial dispersion model equations. Combined models. Discrimination of models for flow systems.
7. Kinetics of heat and mass transfer. Phase equilibrium. Chemical kinetics, chemical equilibrium.
8. Static and dynamic behaviour models.
9. Models of liquid and gases storage tanks dynamic. Models of short and long pipeline dynamics.
10. Models of heat exchanger dynamics - lumped parameter systems
11. Models of heat exchanger dynamics - distributed parameter systems
12. Models of plate and packed column mass exchangers
13. Models of batch and continuous-stirred chemical reactors dynamics.
14. Models of bioreactor dynamics.

Subject Title	**Systems of Ordinary Differential Equations (ODE)**	Number	413 xxx
Semester:	5		
Weekly Load and Assessment:	2/1/1 Ex		
Credit:	5		
Language:	Czech, English		
Prerequisities:	Mathematics I, Mathematics II		
Course provider:	Department of Mathematics		

Module Content:

1. The general dynamical system. Continuous and discrete dynamical system.
2. Autonomous system ODE. A qualitative approach. Phase flow. The notion of stability.
3. Attractor.
4. Planar systems. Phase portraits of linear systems.
5. Phase portraits of nonlinear systems. Grobman -Hartman theorem.
6. First integrals and applications.
7. Phase portraits of linear and nonlinear systems in R^3.
8. Stability theory. Poincare mapping.
9. Nonautonomous systems ODE.
10. Periodic linear systems. Monodromy matrix. Floquet theory.
11. The systems ODE's depending on the parameters. Bifurcations.
12. Examples: "Brusselator", Lorenz system, dumped oscillator.
13. Discrete dynamical systems, basic notions.
14. Regular and chaotic behavior. Liapunov exponents.

Subject Title	Fluid Mechanics and Heat Transfer - I	Number 409xxx
Semester:	M1	
Weekly Load and Assessment:	2/2/0 Ex	
Credit:	5	
Language:	Czech, English	
Prerequisities:	Mathematics I, Unit Operations of Chemical Engineering I	
Course provider:	Department of Chemical Engineering	

Module Content:

1. Introduction to fluid mechanics, history. Hydrostatics.
2. Elements of fluid dynamics. Fluid kinematics. Bernoulli equation and its applications.
3. Conservation of mass, linear momentum and energy. Inviscid flow.
4. Viscous flows. Navier-Stokes equations. Simple solutions for viscous, incompressible fluids.
5. Similitude, dimensional analysis and modelling in fluid mechanics. Viscous flows in pipes.
6. Dimensional analysis of fluid flow in pipes and conduits. Measurements. Turbulence.
7. Reynolds stresses and Reynolds equation. Semi-empirical description of turbulent flows.
8. Introduction to heat transfer. One-dimensional steady-state heat conduction.
9. Unsteady-state one-dimensional heat conduction. Fourier method.
10. Heat convection in laminar fluid flows.
11. Heat transfer at film condensation and free convection.
12. Heat transfer in turbulent flows. Methods of analogy.
13. Heat radiation, fundamental concepts and relations.
14. Radiation shields, effects of radiation on measurement of flowing gas temperature.

Subject Title	Semestral Project in Chemical Engineering	Number 409xxx
Semester:	M1	
Weekly Load and Assessment:	0/3/0 credit with grade	
Credit:	3	
Language:	Czech, English	
Prerequisities:		
Course provider:	Department of Chemical Engineering	

Module Content:

1. Students work individually on topics, which they choose from the list of topics offered and
2. authorized by Institute, and are led by a supervisor. A brief written report on results of work is
3. required, as well as a public presentation in closing seminar. Final evaluation depends on a
4. grade proposed by the project supervisor and on the level of presentation of results.
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Subject Title	Chemical Engineering Thermodynamics	Number	403xxx
Semester:	B5		
Weekly Load and Assessment:	1/2/0 Ex		
Credit:	4		
Language:	Czech, English		
Prerequisities:	Physical Chemistry		
Course provider:	Department of Physical Chemistry		

Module Content:

1. Thermodynamic systems, variables, units, description of states.
2. State behaviour of fluids (ideal gas, real gas, liquids, mixtures).
3. Classification of thermodynamic processes.
4. Changes of energy work and heat. Internal energy an enthalpy.
5. Thermochemistry.
6. Thermodynamic laws and their implications.
7. Chemical equilibrium. Spontaneous chemical reaction
8. Equilibrium constant of chemical reaction. Response of equilibria to the conditions.
9. Chemical equilibrium with enthalpy balance.
10. Phase equilibria of pure substances. Classification of phase transitions.
11. Gibbs phase rule. Phase diagrams.
12. Phase equilibria in one-component systems (fusion, vaporization, sublimation)
13. Phase equilibria in two-component systems. VLE, LLE, SLE.
14. Phase equilibria in multi-component systems.

Subject Title	Unit Operations of Chemical Engineering III	Number	409xxx
Semester:	M1		
Weekly Load and Assessment:	2/2/0 Ex		
Credit:	5		
Language:	Czech, English		
Prerequisities:	Unit Operations od Chemical Engineeering I and II		
Course provider:	Department of Chemical Engineering		

Module Content:

1. Phenomena described by distribution functions. Random processes, basic concepts.
2. Nonideal flow, distribution of residence times, dispersion coefficients.
3. Crystallisation - basic principles, phase equilibria, fractional crystallization.
4. Population balances, crystal size distributions and sieve analysis.
5. Adsorption - simple theory of solute moving through bed, adsorption and desorption waves.
6. Effect of longitudinal dispersion and transport from mobile to stagnant fluid in porous particles.
7. Models of linear and nonlinear sorption.
8. Ionic exchange and electroforetic separation methods.
9. Selection and arrangement of separation methods, criteria for selection.
10. Recycling and regeneration.
11. Combined processes and multifunctional apparatuses, reaction and separation.
12. Strategy of process design and its synthesis.
13. Optimization by parameter selection.
14. Optimization by choices from alternatives.

Subject Title	Measuring and Control Engineering	Number 444xxx
Semester:		
Weekly Load and Assessment:	2/0/2 Ex	
Credit:	4	
Language:	Czech, English	
Prerequisities:	Mathematics, Physics, Chemical Engineering	
Course provider:	Department of Physics and Measurements and Department of Computing and Control Engineering	

Module Content:

1. Basic terms of measurement and control, measurement and control loops in technological charts
2. Analysis of technological systems, mathematical modeling of processes using the mass and energy balances
3. Simulation of processes described by systems of ordinary differential equations using simulation languages
4. Description of dynamic behaviour of systems, their classification, PID control, feedback control loops
5. Methods of controller design, multiple-loop control, basic application of control loops in chemical technology
6. Basic principles of digital signal processing, digital and adaptive controllers
7. Logical control of technological processes, programmable logic controllers (PLC)
8. Industrial measurement; microprocessor supported measurement, intelligent sensors
9. Pressure measurement and pressure transducers
10. Temperature measurement, thermocouples, RTD, thermistors, radiation thermometers
11. Level measurement, mechanical and electrical level sensors
12. Flow measurement, flow sensors, mass-flowmeters
13. Measurement of chemical properties and composition
14. Computer control and information industrial systems – strucutes, main principles of function, design

Subject Title	Enterprise Process Management	Number
Semester:	B2, B6	
Weekly Load and Asse	2/1/0 c,Ex	
Credit:	4	
Language:	Czech	
Prerequisities:	Enterprise Economics	
Course provider:	Department of Economics and Management	

Module Content:

1. Management - structure, functions
2. Corporate planning, strategic planning
3. Concept and stucture of plans
4. Marketing in corporate planning
5. Implementation of marketing strategy
6. Quality management, Environmental management
7. Quality management, Environmental management - methods
8. Management of material flows
9. Supply chain management
10. Organization structure
11. Human resources management
12. Human resources management - team building and forming
13. Information technology in management
14. Controlling

Subject Title	Optimization of Engineering Processes	Number	413 xxx
Semester:	7		
Weekly Load and Assessment:	2/2 Ex		
Credit:	5		
Language:	Czech, English		
Prerequisities:	Mathematics I, Mathematics II		
Course provider:	Department of Mathematics		

Module Content:

1. Formulation of optimization problem.
2. Extrema of functions of real variables-methods of classical analysis.
3. Free extremum, extremum with equality constraints.
4. Extremum with inequality constraints.
5. Linear programming.
6. Simplex method.
7. Nonlinear programming.
8. Methods of adaptive search.
9. Gradient methods.
10. Penalty functions.
11. Elements of dynamic programming.
12. Example of sources distribution.
13. Vector optimization.
14. Construction of Pareto compromise set.

Subject Title	Software for Chemical Engineers	Number 409xxx
Semester:	M1	
Weekly Load and Assessment:	2/2/0 Ex	
Credit:	5	
Language:	Czech, English	
Prerequisities:	Basic skils concerning the work on PC under OS Windows.	
Course provider:	Department of Chemical Engineering	

Module Content:

1. Introduction. Types of software products. SW life cycle. Chemical engineering problems and their solution with SW.
2. General approach to the design of SW. Analysis of the problem and conceptual design.
3. Programming languages, their types. Characteristics and typical use of most common languages. Processing of the program source code. Compilers and linkers.
4. Programming technologies for effective development of programs. Structured programming.
5. Programming language FORTRAN - architecture, construction of a program, data types, declarations, expressions.
6. Programming language FORTRAN - commands, input/output operations.
7. Work in the integrated environment of DIGITAL (Compaq) Visual Fortran.
8. Utilisation of libraries. Specialised libraries of mathematical and numerical methods. IMSL, NAG, etc.
9. Integrated mathematical software - generally. Numeric, symbolic and graphical operations.
10. System Polymath, purpose and utilisation.
11. System Maple - environment and basic operations.
12. System Maple - solution of chemical engineering problems.
13. System MATLAB - environment and basic operations.
14. System MATLAB - solution of chemical engineering problems.

Subject Title	Mass Transfer Processes	Number 409xxx
Semester:	M2	
Weekly Load and Assessment:	3/3 Ex	
Credit:	7	
Language:	Czech	
Prerequisities:	Physical Chemistry, Unit Operations of Chemical Engineering	
Course provider:	Department of Chemical Engineering	

Module Content:

1. Equilibrium stage concept, equilibrium diagrams, distribution coefficients.
2. Balances, degrees of freedom, multicomponent flash distillation.
3. Single-stage operations, processes with chemical reaction.
4. Differential distillation, extraction, absorption.
5. Multi-stage contactors, binary distillation, efficiency.
6. Ternary extraction, leaching, distillation, extractive and azeotropic distillation.
7. Multicomponent separations: short-cut methods, difference equations.
8. Multicomponent separations: rigorous methods.
9. Batch distillation. Entrainment, backflow model.
10. Diffusion, Fick‘s laws, Stefan-Maxwell equation, eddy diffusion.
11. Steady-state diffusion, diffusion with convection, film theory.
12. Unsteady-state diffusion, penetration and surface-renewal theories.
13. Diffusion and chemical reaction, enhancement factor.
14. Differential contactors, transfer units, axial dispersion, stage efficiency.

Subject Title	Process and System Design	Number 409xxx
Semester:	M2	
Weekly Load and Assessment:	3/1/0 Ex	
Credit:	5	
Language:	Czech, English	
Prerequisities:		
Course provider:	Department of Chemical Engineering	

Module Content:

1. Theory of systems and chemical engineerig. Team work. Computers in process design.
2. Graphs, flowsheets, process flow diagramms.
3. Balance calculation based on specified data.Overdetermined and underdetermined systems.
4. Balance calculation based on measured data. Reconciliation.Design of measurements.
5. Modelling of unit operations.Linear, rigorous,short-cut, fuzzy models.
6. Steady state simulation. Sequential-modular approach.Equation oriented approach.
7. Physical-chemical models for simulation. Databases for chemical-physical data.
8. Architecture of some commercial simulation programms (ASPEN Plus)
9. Cost engineering calculations.
10. Optimisation of chemical engineering processes.
11. Synthesis. Heuristical and evolutional algorithms.
12. Design of heat exchanger networks
13. Batch and periodical processes. Dynamic balance calculation. Dynamic simulation.
14. Conceptual and detailed process design

Subject Title	Specialized Laboratory I	Number 409xxx
Semester:	M3	
Weekly Load and Assessment:	0/3/0 credit with grade	
Credit:	3	
Language:	Czech, English	
Prerequisities:		
Course provider:	Department of Chemical Engineering	

Module Content:

1. The goal of this course is to introduce students to research activities of the Department of
2. Chemical Engineering and in its organizational structure (research groups).
3. The students, usually in groups of 2-3, are given simple problems provided by
4. research groups. The solution process is supervised by an appointed teacher.
5. Later on students work individually under personal supervision of staff members.
6. Each student choses topic of his/her work from the list of problems, offered and approved by
7. the department. Final classification summarizes results of the introductory part of the course
8. and classification of the individuall work stated by the supervisor.

Subject Title	Methods of Applied Mathematics	Number	413 xxx
Semester:	8		
Weekly Load and Assessment:	2/0 Ex		
Credit:	3		
Language:	Czech, English		
Prerequisities:	Mathematics I,II, Systems of ODE, Dynamical Systems and PDE's		
Course provider:	Department of Mathematics		

Module Content:

1. Stability of steady state solutions.
2. Point and essential spectrum.
3. Stability of wave solutions of the reaction-diffusion systems.
4. Curvilinear coordinates.
5. Operators grad, div, rot in curvilinear coordinates
6. Curvature of planar curves and surfaces.
7. Propagation of the curvilinear fronts in the reaction-diffusion systems.
8. Propagation of the curvilinear fronts in the reaction-diffusion systems.
9. The method of weighted residuals.
10. Variational methods
11. Introduction to the finite element method
12. Development of finite element equations.
13. Steps in performing finite element analyses.
14. Applications of the finite element method.

Subject Title	Dynamical Systems and PDE's	Number 413 xxx
Semester:	6	
Weekly Load and Assessment:	3/0 Ex	
Credit:	4	
Language:	Czech, English	
Prerequisities:	Mathematics I, II, Systems of ordinary diff. Equations	
Course provider:	Department of Mathematics	

Module Content:

1. PDE's as the dynamical system.
2. Elements of functional analysis, spectral theory.
3. Stability of steady state solutions.
4. Fourier series.
5. Fourier method.
6. Modified Fourier Methods.
7. Wave solutions of PDE's . 1-dimensional case.
8. Planar wave solutions. Spiral waves.
9. Elements of vector analysis.
10. Elements of vector analysis.
11. Reaction-diffusion equations.
12. Turing instabilities.
13. Turing instabilities.
14. Applications.

Subject Title	Engineering Methods in Biological Processes	Number	409xxx
Semester:	B5, M2		
Weekly Load and Assessment:	2/1/0 Ex		
Credit:	4		
Language:	Czech, English		
Prerequisities:	Mathematics I, Unit Operations of Chemical Engineering I		
Course provider:	Department of Chemical Engineering		

Module Content:

1. Introduction. Elements of cell biology.
2. Enzymes: structure, mechanism of action, kinetics, immobilization, applications.
3. Elementary cell physiology.Metabolic control.Metabolic pathways.Energy production in cells.
4. Elements of genetic engineering. Genetically modified organisms.
5. Cell growth, batch and continuous cultures. Kinetics of microbial growth.
6. Structured and unstructured models of cell growth. Mass-transport and cell growth.
7. Stoichiometry and energy aspects of cell growth. Stoichiometry of product formation.
8. Metabolic flux analysis. Control of metabolic pathways, metabolic engineering.
9. Fermenters and bioreactors. Choice of cultivation method. Batch and continuous cultivation.
10. Choice of bioreactor, scale-up, control. Modelling of bioreactors.
11. Isolation and purification of microbial products.
12. Mixed microbial populations in nature and industry. Modelling and analysis, applications.
13. Bioprocesses based on application of plant cell cultures. Reactors, cultivation methods.
14. Bioprocesses based on application of mammalian cell cultures. Reactors, cultivation methods.

Subject Title	Product Engineering	Number 409xxx
Semester:	M2	
Weekly Load and Assessment:	2/1/0 Ex	
Credit:	4	
Language:	Czech, English	
Prerequisities:	Mathematics I, Unit Operations I, Physical Chemistry I	
Course provider:	Department of Chemical Engineering	

Module Content:

1. Mechanical properties of materials. Plasticity, visco-elasticity. Anisotropic materials.
2. Surface properties of materials. Surface tension, wettability, surface conductivity. Adsorption.
3. Polydisperse systems and their characterization. Method of population balances.
4. Stability of dispersions. Agglomeration, coagulation, physical and chemical gelation.Colloids.
5. Transport of mass, momentum, heat and charge in materials. Complex rheology, thixotropy.
6. Crystalline, semi-crystalline and amorphous materials. Liquid crystals, glassy materials.
7. Types of dispersions. Suspension, emulsion, smoke, mist, foam, paste, aerosol, alloy.
8. Production of various dispersions in food industry. Detergents, paints and varnishes.
9. Porous materials. Granulation, precipitation, calcination. Zeolites, molecular sieves.
10. Polymers, their molecular and meso-scopic architecture. Processing of plastics.
11. New materials for fuel cells and micro-electronics. Solid-phase electrolytes.
12. Materials for tissue engineering. Cellular structure of materials and biomaterials.
13. Nano-structured materials. Surface modification of materials, deposition of surface layers.
14. Primary to quaternary recyling of material and energy content of wastes.

Subject Title	Reactor and Bioreactor Engineering	Number 409xxx
Semester:	M3	
Weekly Load and Assessment:	4/2/0 Ex	
Credit:	8	
Language:	Czech, English	
Prerequisities:	Unit Operations of Chemical Engineering I and II	
Course provider:	Department of Chemical Engineering	

Module Content:

1. Mass and energy balances of reacting systems.
2. Kinetics and stoichiometry of chemical reactions; design of isothermal reactors.
3. Complex chemical reactions, reaction mechanisms.
4. Measurement and evaluation of kinetic data.
5. Design of non-isothermal reactors; steady state and dynamic behaviour.
6. Diffusion and reaction in porous catalyst.
7. Catalytic reactors.
8. Distribution of residence times in chemical reactors; nonlinear reactors.
9. Biotechnology and bioengineering; production of insuline.
10. Kinetics of cell growth, batch and continuous culture, structured models.
11. Bioreactors; enzyme reactors; chemostat; fed-batch bioreactor.
12. Immobilized enzyme and cell systems; diffusion limitation.
13. Isolation and separation of biological product.
14. Fermentation of baker yeast and production of monoclonal antibodies.

Subject Title	Process Design	Number 409xxx
Semester:	M3	
Weekly Load and Assessment:	0/4/0 credit with grade	
Credit:	4	
Language:	Czech, English	
Prerequisities:	Process and System Design	
Course provider:	Department of Chemical Engineering	

Module Content:

1. Problem formulation.
2. Conceptual process design.
3. Application of commercial simulation programs.
4. Elaboration of project.Consultation.
5. Controlling day.
6. Elaboration of project.Consultation.
7. Excursions.Exhibitions. Contact with practice.
8. Elaboration of project.Consultation.
9. Elaboration of project.Consultation.
10. Elaboration of project.Consultation.
11. Working out of written report.
12. Controlling day.
13. Submission of report.
14. Defence of submitted report. Examination.

Subject Title	Specialized Laboratory II	Number 409xxx
Semester:	M2	
Weekly Load and Assessment:	0/4/0 credit with grade	
Credit:	4	
Language:	Czech, English	
Prerequisities:		
Course provider:	Department of Chemical Engineering	

Module Content:

The goal of this subject is to involve graduate students deeper in research activities of the department. They learn basic principles of scientific work, methods of obtaining and processing data and presentation of results. Students work on problems, that they choose from the list offered and approved by the department. Each student is supervised by an appointed staff member. Students typically continue to solve problems of Spec. Lab. I . A brief written report is required as well as public presentation of the results at a closing micro-conference of all students. The evaluation combines the grade proposed by the supervisor and the level of presentation of results.

Subject Title	Process Safety and Reliability	Number 409xxx
Semester:	M3	
Weekly Load and Assessment:	2/1/0 Ex	
Credit:	4	
Language:	Czech, English	
Prerequisities:		
Course provider:	Department of Chemical Engineering	

Module Content:

1. Nature of the accident process. Acceptable risk.
2. Accident and loss statistic.Three significant disasters.
3. Toxicology.Models of dose:response curves.Probits.
4. MSDSs.Treshold limity values. Industrial hygiene.Dust and noise as risk factors.
5. Vaporation rate of liquid during vessel filling.Ventilation.
6. Source models for releases of vapours and liquids through holes and pipes.
7. Toxic release and dispersion models.Pasquill-Gifford model.
8. Explosions of flammable dusts and gases.Flammability characteristics.Ignition and oxidation.
9. Explosions of the vapor cloud and boiling liquid expanding vapor. Efficiency of explosions and
10. Fire and explosion prevention.Inerting.Controlling static electricity.Ventilation.Sprinkler system
11. Probability theory of failures for elements and systems.Intensity of failures.Weibull analysis.
12. Event trees.Fault trees.
13. Case histories. Human error function.Learning from accidents.
14. Hazard and operability studies (HAZOP), DOW index of explosion and toxicity.

Subject Title	Information Sources	Number	445xxx
Semester:			
Weekly Load and Assessment:	1/1/0		
Credit:	2		
Language:	Czech, English		
Prerequisities:	none		
Course provider:	Department of Computing and Control Engineering		

Module Content:

1. Primary and secondary chemical literature, in-house library, key words
2. Printed, online, networked sources of information
3. Searching scientific information, style of citation
4. Chemical Abstract Service (CAS)
5. Using of „CA on CD“; browse, search, save and print tools
6. SciFinder
7. ScienceDirect, Medline
8. Web of Science
9. Large databases: Gmelin, Beilstein, Ullmann
10. Libraries: university, national, technical. On-line catalogues
11. Scientific journals, electronic journals, Elsevier, Springer
12. Searching scientific information on the Internet, ProQuest-PCI
13. Dictionaries, sources of chemical and physical data
14. Transfer of information data to different programs, bibliographical databases

Subject Title	Information and Database Systems	Number 409xxx
Semester:	M3	
Weekly Load and Assessment:	2/2/0 Ex	
Credit:	5	
Language:	Czech, English	
Prerequisities:	None	
Course provider:	Department of Chemical Engineering	

Module Content:

1. Introduction. Examples of database and information systems. Area of interest.
2. Mathematical background (relations, relational algebra, relational calculus).
3. Systematic development of database and information systems, degrees of formalization and abstraction.
4. Real world and the analyses of the area of interest. Gaining knowledge about data, information, dataflows, workflows, functions, states, decisions.
5. Conceptual design. Entities, occurrences of entities, attributes, domains, relations. ER diagrams, DF diagrams and other schemes for conceptual modeling. CASE systems.
6. Implementation design. Database models.
7. Relational databases. Normalization of data structures, normal forms. Integrity conditions.
8. Object oriented databases and their design.
9. Physical database implementation design. Implementation phase.
10. Environments for the development of database systems. Specialized database languages.
11. Development environments under OS Windows. Interactive work, programming.
12. Database languages SQL and 4GL.
13. Database servers and the architecture client-server. MySQL and MS SQL Server.
14. Utilization of database systems in computer networks with concurrent access. Protection of data and preservation of their consistency.

Subject Title	Computer Aided Simulation of Processes	Number	445xxx
Semester:	M3		
Weekly Load and Assessment:	2/0/2 Ex		
Credit:	4		
Language:	Czech, English		
Prerequisities:	Chemical Engineering		
Course provider:	Department of Computing and Control Engineering		

Module Content:

1. Introduction, system approach to process problem solution.
2. Sequential-modular methods of simulation, simulation programs and their architecture.
3. Unit operation models library, thermodynamic models and data banks of thd. data.
4. Process simulator HYSYS – simulation of propylene glycol production.
5. Object structure of HYSYS – simulation with several thermodynamic models.
6. Project 1: Simulation of a simple plant (sensitivity analysis).
7. Processes with recycle - optimization of ethylene chloride production.
8. Project 2: Simulation of a complex plant (controlled simulation).
9. Possibilities of customization of HYSYS, case study of HYSYS extension.
10. Equation-oriented approach to solution of mathematical models, complexity of algorithms.
11. Graphs, terminology and basic definitions, graph description and coding, graph searching.
12. Decomposition of model equation sets into irreducible subsystems.
13. Optimum sequencing for simulation calculations, strong components of graphs.
14. Project 3: Decomposition of a simple model, optimum sequence of simulation calculations.