The Faculty of Chemistry
Plan and program

of the 1st degree studies (Engineering studies)

Chemical and Process Engineering

Selectable courses:

Product design and engineering of pro-ecological processes

Processing of polymer materials

Graduate professional profile (1st Degree)

Chemical and Process Engineering course graduate students achieve marketable, interdisciplinary technical education in the broad sense of process engineering, very useful for engineers, technologists and designers in chemical, pharmaceutical, cosmetic, polymer processing and food industry as well as biotechnology, energetics and environmental protection. Graduate students represent in-demand engineer and management staff for almost all branches of processing industry. They are also valued employees of design workshops and bureaus, industrial laboratories of research and development.

Courses structure

The study plan for the BSc course in Chemical and Process Engineering is presented in the enclosed tables. Subjects are described by: name of the individual subject, type of classes (L – lectures, C – theoretical classes, P – project, Lb – laboratory), number of hours per semester (each lasting 15 weeks) and number of ECTS credits. The grey colour and a bold typestyle mean that the examination is obligatory. To grant the professional title of a Bachelor of Science it is necessary to complete the study program, to prepare and defend a BSc thesis. Before the defense of the engineering thesis the final examination is carried out.

CHEMICAL AND PROCESS ENGINEERING

L.p.	Department	Group of training modules W01 in mathematics, physics and chemistry	Sem.	I					II					III					IV					V					VI					VII				
			total	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P
1	CF	Instrumential analysis	60																					4	30		30											
2	CN	Analytical chemistry	45																3	15		30																
3	CF	**Physical chemistry**	165											**6**	**30**	**30**	**15**		**6**	**30**	**30**	**30**																
4	CN	**General and inorganic chemistry**	135	**6**	**30**	**30**			**6**	**30**	**15**	**30**																										
5	CD	**Organic chemistry**	90											**7**	**30**	**30**	**30**		-	-	-	-																
6	FF	**Physics**	105	**6**	**30**	**30**			**6**	**15**	**15**	**15**																										
7	FM	**Mathematics**	150	**8**	**30**	**30**			**6**	**30**	**30**			2	15	15																						
		TOTAL	**750**	20	90	90	0	0	18	75	60	45	0	15	75	75	45	0	9	45	30	60	0	4	30	0	30	0	0	0	0	0	0	0	0	0	0	0

CHEMICAL AND PROCESS ENGINEERING

L.p.	Department	**Group of training modules W02 in general engineering activity**	Sem.	I					II					III					IV					V					VI					VII				
			total	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P
8	ZB	Technical safety and ergonomics	15	1	15																																	
9	CB	Scientific and technological information	2											0			2																					
10	CI	Computer engineering graphics (CAD)	60						4	15		45																									
11	CI	Technical mechanics and machines theory	105	4	30	30			3	30			15																								
12	EM	Metrology and industrial measurements	30						2	15		15																									
13	CI	Packages of application software	30											2			30																					
14	CM	Introduction to materials science	30	2	15	15																															
15	CB	Fundamentals of programming	30											2			30																					
16	CI	Parametric design in Autodesk Inventor	20											2			20																					
17	CB	Statistics and results elaboration	30											2	15		15																					
18	CB	Computer science	45						3	15		30																									
		TOTAL	**397**	7	60	45	0	0	12	75	0	90	15	8	15	0	97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

CHEMICAL AND PROCESS ENGINEERING

L.p.	Department	Group of training modules W03 in chemical engineering and technology	Sem.	I					II					III					IV					V					VI					VII				
			total	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P
19	CM (W) CS(L)	**Polymer chemistry and technology**	60																									**4**	**30**		**30**						
20	CM	**Engineering materials**	60																					**4**	**30**		**30**										
21	CI	**Fluid dynamics**	60											**5**	**30**	**30**																					
22	CI/CK	CFD flow modeling	30																					2				30									
23	CI	**Fundamentals of heat and mass transfer**	60																**5**	**30**	**30**																
24	CI	Fundamentals of chemical technology	60																5	30	30																
25	CI	**Industry processes and process apparatus, process intensification**	105																4	30	15			**4**	**15**	**15**	**15**	**15**									
26	CI	Heat transfer process apparatus design	45																					2	15		15	15									
27	CI	Process design	45																															2	15			30
28	CI	Chemical reactors	60																															3	30	30		
29	CM	Chemical technology	75																					4	30		45										
30	CI	**Engineering thermodynamics**	60																**5**	**30**	**30**																
		TOTAL	**720**	0	0	0	0	0	0	0	0	0	0	5	30	30	0	0	19	120	105	0	0	16	90	15	105	60	4	30	0	30	0	5	45	30	0	30

CHEMICAL AND PROCESS ENGINEERING

L.p.	Department	Other modules	Sem.	I					II					III					IV					V					VI					VII				
			total	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P
31	DJ	**Foreign language**	120											2		30			2		30			2		30			**3**		**30**							
32	DF	Physical education	60											0		30			0		30																	
		TOTAL	**180**	0	0	0	0	0	0	0	0	0	0	2	0	60	0	0	2	0	60	0	0	2	0	30	0	0	3	0	30	0	0	0	0	0	0	0
L.p.	Department	**Group of training modules in humanistic and economic**	Sem.	I					II					III					IV					V					VI					VII				
			total	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P
33	ZH	Academic savoir-vivre	10	1	10																																	
34	ZM	Social competence	25																															2	10	15		
35	ZO	Economic course*	30	2	30																																	
		TOTAL	**65**	3	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	10	15	0	0
L.p.	Department	**Group of diploma modules and practice**	Sem.	I					II					III					IV					V					VI					VII				
			total	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P
36		Diploma thesis	150																															15			150	
37		Professional training	0																										4	4 weeks								
38		Diploma seminar	15																															2			15	
		TOTAL	**165**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	17	0	0	165	0
		TOTAL	**2277**	**30**	**190**	**135**	**0**	**0**	**30**	**150**	**60**	**135**	**15**	**30**	**120**	**165**	**142**	**0**	**30**	**165**	**195**	**60**	**0**	**22**	**120**	**45**	**135**	**60**	**11**	**30**	**30**	**30**	**0**	**24**	**55**	**45**	**165**	**30**
				325					**360**					**427**					**420**					**360**					**90**					**295**				

35	***Economic course**
ZO	Fundamentals of economics
ZO	Fundamentals of management

Speciality: product design and engineering of pro-ecological processes

L.p.	Department	Elective modules I W04	Sem.	I					II					III					IV					V					VI					VII				
			total	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P
39	CI	**Diffusion separation processes**	120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**4**	**30**	**15**		**15**	**4**	**15**	**15**	**15**	**15**					
40	CI	Engineering of powder materials	30																															2	15	15		
41	CI/BT	Waste treatment engineering	45																									4	15		15	15						
42	CI/CM	Product engineering	30																					2	15		15											
43	CN	Environmental engineering	30																														2	30				
44	CI	Engineering of the sustainable industrial processess	30																									3	15			15						
45	CI	3D Computer Aided Design	30																					2			30											
46	CI/CN	Renewable sources of energy and energy-saving technologies	45																														2	30				15
47	CI	**Selected unit operation**	75																									8	**30**	**15**	**15**	**15**						
		TOTAL	**435**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	45	15	45	15	19	75	30	45	60	6	75	15	0	15
			2712	**30**	**190**	**135**	**0**	**0**	**30**	**150**	**60**	**135**	**15**	**30**	**120**	**165**	**142**	**0**	**30**	**165**	**195**	**60**	**0**	**30**	**165**	**60**	**180**	**75**	**30**	**105**	**60**	**75**	**60**	**30**	**130**	**60**	**165**	**45**
		TOTAL		weekly			22					24					28					28					32					20					27		
				in semester			**325**					**360**					**427**					**420**					**480**					**300**					**400**		

Speciality: processing of polymer materials

L.p.	Department	Elective modules II W04	Sem.	I					II					III					IV					V					VI					VII				
			total	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P	ECTS	L	C	Lb	P
48	CI	**Diffusion separation processes**	105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**3**	**30**	**15**			**4**	**15**	**15**	**15**	**15**					
49	CM	Elements of rheology in polymer processing	45																					3	15		30											
50	CM	Evaluation of practical properties of polymer materials	30																										2	15		15						
51	MK	Fundamentals of CAD/CAE in polymer processing	45																															4	15		30	
52	CS	Modern modification methods of the polymer materials	35																										3	15		20						
53	CD	Modern polymer technologies	25																										2	15		10						
54	CM	Industrial polymer materials	15																															2	15			
55	CM	Technology of monomers	30																					2	15		15											
56	CM	**Processing technology of polymer materials**	105																										**8**	**30**		**60**	**15**					
		TOTAL)	**435**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	60	15	45	0	19	90	15	120	30	6	30	0	30	0
			2712	**30**	**190**	**135**	**0**	**0**	**30**	**150**	**60**	**135**	**15**	**30**	**120**	**165**	**142**	**0**	**30**	**165**	**195**	**60**	**0**	**30**	**180**	**60**	**180**	**60**	**30**	**120**	**45**	**150**	**30**	**30**	**85**	**45**	**195**	**30**
		TOTAL		weekly			22					24					28					28					32					23					24			
				in semester			**325**					**360**					**427**					**420**					**480**					**345**					**355**			

Speciality	Total sum of L, C, Lb and P	Fraction of C, Lb and P, %	elective ECTS points
Product design and engineering of pro-ecological processes	**2712,0**	**0,62**	**63**
Processing of polymer materials	**2712,0**	**0,63**	**63**

Framework programs

of the 1st degree studies (Engineering studies)

Chemical and Process Engineering

Instrumental analysis

The role and tasks of instrumental analysis in industrial processes. Samples acquisition, storage and preparation for analysis. Calibration and calibration plots. Errors of analysis. Optical methods. Polarimetry. Quantitative analysis of elements and compounds using spectroscopic methods. Atomic Emission Spectroscopy. Atomic Absorption Spectroscopy (AAS) principles and applications. Absorption spectroscopy in UV/VIS. IR absorption spectroscopy. Basic principles of magnetic nuclear resonance. Principles of mass spectrometry of organic compounds. Chromatographic methods. Gas chromatography. High performance liquid chromatography (HPLC). Electroanalytical methods. Voltammetric methods - the main techniques. Complementarity of instrumental methods. Hyphenated methods. Criteria of choice of the analytical methods.

Analytical chemistry

Division of analytical chemistry, scale, accuracy and precision of the methods. General scheme of quantitative analysis. Analytical errors, statistical evaluation of results. Methods of separation and concentration. Division and characteristics of chemical analysis methods. Contemporary theories of acids and bases, protolytic solvents, equilibrium constants. solubility and solubility product. Theoretical basics of volumetric analysis: acid-base, oxidation-reduction and complexation titrations. Precipitation analysis, effects accompanying solid product separation. Division and characteristics of selected instrumental methods. Chemical calculations in the field of volumetric and gravimetric methods.

Physical chemistry

The theory of perfect gases. Equations of state. The theories of real gases. Chemical thermodynamics. System. Surroundings. Work. Heat. Cyclic processes. Reversible processes. The first law of thermodynamics. Internal energy. Enthalpy. Heat capacity of gases, liquids and solids. Thermochemistry. Enthalpy of formation of compounds. Heat of solubility. Bond energy. The temperature dependence of reaction rate on temperature. The second and the third law of thermodynamics. Carnot cycle. Entropy. Gibbs energy. Helmholtz energy. Chemical potential. Interatomic and intermolecular interactions. Viscosity and surface tension of liquids. Phase equilibria and diagrams. Clapeyron equation. Clausius-Clapeyron equation. Thermodynamics of ideal solutions. Activity. Boiling temperature – composition diagrams of two-component solutions. Azeotropes. Colligative

properties. Colloidal solutions, micelles. Chemical equilibrium. Gibbs energy function. The influence of pressure and temperature on chemical equilibrium. Chemical kinetics. The rate and the order of reaction. Arrhenius theory and transition state theory. Complex reactions. Basics of the kinetics of enzymatic reactions. Basics of catalysis. Adsorption. Adsorption theories. Electrolyte solutions. Thermodynamics of electrolyte solutions. Electrochemistry. Electrochemical half-cells and cells. Thermodynamics of electrochemical cell. Physicochemical applications of electrochemical measurements. Batteries and fuel cells. Theoretical basics of molecular spectroscopy. Symmetry elements.

General and inorganic chemistry

Concepts and chemical laws. Structure of atom. Periodicity of chemical properties. Metals and non-metals. Chemical bonds. Covalent bonds. Formal oxidation state. Molecular orbital and valence bond theory. States of matter. Phase transitions. Gas state. Ideal gas state equation. Units of matter. Solid state. Ionic and molecular crystals. Liquids and solutions. Units of concentration. Electrochemical processes and corrosion. Chemical equilibrium. Mass action law. Colligative properties. Electrolytic dissociation. Strong and weak electrolytes. Acids and bases. Ampholytes. Buffer solutions. Thermochemistry and thermodynamics. Inorganic compounds, classification and terminology. Properties of elements. Main group metals (1, 2, 13). Elements of group 14-18. D-block elements. Crystal field theory. Spectroscopic and magnetic properties. F-block elements. Complex compounds.

Organic chemistry

Structure and isomerism of organic compounds. Effects of electronic displacements versus explanation of properties of organic compounds. Classification of organic compounds. Basis of chemical nomenclature. Saturated and unsaturated hydrocarbons (alkene, alkadiene and alkyne). Aromatic hydrocarbons – derivatives of benzene. Halogen derivatives of hydrocarbons. Alcohols, phenols and ethers. Aldehydes and ketones. Mono- and policarboxylic acids. Halo-, hydroxy- and oxoacids.

Physics

Dimensional analysis. Functions of one and several variables. Scalars and vectors. Derivatives in physics. Coordinate Systems. Motion along a straight line. Motion in two or three dimensions. Newton’s laws of motion. Potential energy. Periodic motion, differential equations and complex numbers in physics, resonance. Mechanical waves, wave phenomena, acoustics: sound and hearing. Fluid Mechanics. Introduction to thermodynamics: temperature and heat. Laws of thermodynamics, entropy. Introduction to electromagnetism: electric charge and electric field, Gauss’s law, work and electric potential. Capacitance and dielectrics. Conductors, electric current, resistance, circuits and electromotive force. Magnetic field. Hall effect, cyclotron, mass spectrometer. The phenomenon of magnetic induction. Electromagnetic waves. Introduction to modern physics and quantum mechanics. Wave-particle duality of light and matter. Probability and

uncertainty principle Schrodinger equation. Free particle, particle in potential well, stationary states, atomic structure, condensed matter. Introduction to nuclear physics, nuclear reactions, nuclear power, stability and radioactivity, biological effects of radiation.

Mathematics

Elements of mathematical logic and set theory. Basic properties functions of one real variable, polynomials. Sequences of numbers. Series of numbers. Limit and continuity of function of real variable. Differential calculus of function of one real variable. Integral calculus of function of one real variable. The set of complex numbers. Matrices. Ordinary differential equations. Elements of calculus of vectors and analytic geometry. Basic properties of function of several variables. Scalar n-order ODE and first-order system ODEs. First-order linear systems of ODEs. Initial-value and boundary-value problems for PDEs. Fourier series. Trigonometric series. Canonical forms of second-order linear PDEs.

Technical safety and ergonomics

Legislation in the field of labour protection. Subject matter and scope of work safety and ergonomics. Models of accidents at work. Ergonomic aspects of the system human – machine – environment. The study of the burden of mental work. Dangerous and harmful factors connected with work process and working conditions. Ergonomic factors in the organization of work. University procedures applied in case of accidents and emergencies (fire, accident, etc.) pre-medical aid rules, fire protection (including evacuation).

Scientific and technological information

Searching for information on the most abstracts and bibliographic important publishing houses (Chemical Abstracts) with the use of index. Search for chemical information in scientific journals available on-line from the Rzeszów University of Technology library.

Computer engineering graphics (CAD)

Rectangular projections, axonometric projection, views and sectional views. Rules for dimensioning. Connections of the machines: separable and inseparable. Assembly drawings. Technical charts. Standardized graphical symbols and devices used in the processes of chemical technology. Exercises for features and commands of AutoCAD. Examples of AutoCAD specific functions application. Creating a simple technical drawing. Making production and assembly drawings of machines parts. Reading the technical documentation.

Technical mechanics and machines theory

Basic terms and concepts of mechanics. Flat, convergent arrangement of forces. Moment of force. Reduction and equilibrium of planar systems forces converging and arbitrary. The sliding and rolling friction. The center of gravity. The moment of inertia. Basic terms and concepts of the strength of materials. Mechanical properties of construction materials. Basic cases of stress. General rules of designing and construction of chemical apparatus. Standards and standardization. Basic constructive materials used in construction of chemical apparatus. Machines review and basic machine parts of general purpose.

Metrology and industrial measurements

Basic concepts of law and industrial metrology. Historical outline. International System of Units. Standards of physical quantities. Measurement traceability. Defining of the measure and mathematical model of measurement result. Direct and indirect measurement method. Validation of measurement method. Indicated value and measured value. Basic measurement equipment. Essential concepts of measurement: accuracy, error, uncertainty, trueness, precision, repeatability, reproducibility. Measurement error, instrumental error, measurement method error, correction factor. Uncertainty of measurement result. Ways of declaration of accuracy of measurement equipment. Relative and absolute maximum permissible error of indication of measurement equipment. Estimation of standard uncertainty with method type A and method type B. Calculation of combined uncertainty and expanded uncertainty. Worst distribution method. Verification, calibration, legalization and adjustment of measurement equipment. Basics of operation of measurement instruments and performing of correct measurements. Types and specificity of casual, cognitive and verification measurement. Function of presence of physical quantity standard during measurement. Notation and interpretation of measurement result. Time consuming and cost consuming. Decision criteria: quality, reliability and applicability of performed measurement.

Packages of application software

Application of MS Excel to discretize example mathematical functions, to create simple and advanced plot charts, to perform array operations, statistical analysis and to work with macros. Application of Origin Lab software to prepare professional charts, to execute statistical processing of experimental data, to estimate parameters for equation describing experimental data. Use of Matlab and/or Maple programs for arithmetic calculations, algebraic transformations, solution of linear and nonlinear equations, symbolic and numerical function integration and differentiation, matrix algebra, solving differential equations. Introduction to programming in Matlab and/or Maple.

Introduction to materials science

Definition of material, classification of materials in terms of arrangement. The basic terms of crystallography. Miller indices of planes. Crystallographic systems. Atom radius and ion radius. Coordination numbers and figures. Symmetry of crystals. Elements of group theory. Classification of crystals in terms of chemical bonding. Monocrystals and polycrystals. Bravais lattice. Crystal lattice nodes. Dense structure pose. Octahedral and tetrahedral gaps. Allotropy and polymorphism. Real crystals. Point defects, dislocations, plane defects. Volume and crystallographic density of an unit cell.

Fundamentals of programming

Getting to know the C++ programming environment. Creation a sample program to acquaint the structures, data types and the main control instructions in C++. Preparation of the own program project and algorithm development. Implementing the program using elements of object-oriented programming. Running and testing the computer program. Developing of the program documentation.

Parametric design in Autodesk Inventor

Autodesk Inventor interface. Parametric drawing of figures on the plane - use of geometric and dimensional constraints. Different drawing methods for obtaining the same solid model. Detecting and correction of errors. Tools for creating and modifying 3D elements. Construction elements. Determining the properties of subassembly. Saving the components of the designed unit. Unit assembly of parts - defining degrees of freedom, unit constraints and movement. Using the base of ready-to-use elements. Creating two-dimensional documentation. Individual design of chemical equipment part.

Statistics and results elaboration

LIMS (Laboratory Information Management System). Experimental database. Exploratory data analysis of the analytical measurements. Statistical hypothesis testing. Multiple regression. One-way and multiple analysis of variance. Management of Statistica program data. Study of empirical variable distribution. Statistical inference - parametric tests. Analysis of Variance.

Computer science

Computer networks. Internet basics. Microsoft Office package: Word, Excel, PowerPoint. Development of laboratory data. Chemical structure editors. Definitions of basic concepts: the algorithm, computer program, computer system, IT system, the operating system. Operating systems and their types. Computer programs, utilities and tools. Telecommunications systems. Websites construction. Representation formalisms of

algorithms: data flow diagram, program flow diagram. The basic elements of the configuration of software environment and compiler for C++. Main control statements in C++. Static and dynamic variables.

Polymer chemistry and technology

Classification of polymers, examples of polymer types. Structure of macromolecules vs. physical properties of polymers. Condensation polymers. Thermodynamic principles of polymerization. Radical polymerization. Ionic polymerization of unsaturated monomers. Copolymerization. Ring-opening polymerization. Polymer tacticity. Reactions on polymers. Chemical modification of polymers. Native polymers. Biopolymers.

Engineering materials

Metallic materials. Ceramic materials. Polymeric materials. Composites, properties of composites. Modulus of elasticity. Yield strength, tensile strength, hardness and ductility. Sudden cracking, toughness and fatigue of materials. The deformation and cracking as a result of creep. Oxidation and corrosion. Friction and attrition caused by friction. Selection of materials.

Fluid dynamics

Operator of gradient, divergence and rotation. Surface and volume integrals. Ordinal differential equations, sets of differential equations, method of integration. Partial differential equations, Fourier method of solution, method of Laplace transform. Ideal and real fluids, forces acting in fluids. Fluid statics, equilibrium conditions. Fluid kinematics. Analytical methods of fluid kinematics. Continuity equation, Euler equation of motion. Laminar and turbulent flow. Boundary layer. General and differential momentum and mass balances. Theory of turbulence - elements. Elements of rheology. Flow through porous media. Dimensionless analysis.

CFD flow modeling

Work in sketchpad mod. 2D modeling. Simplifying and repairing of geometry. Parametrization of geometry. Mesh generation in Ansys Meshing software. Types of calculation meshes. Meshing algorithms. Control of quality and size of the mesh. Methodology of mesh generation for CFD analysis. Basics of Fluent Software. Determination of flow model. Determination of boundary conditions. Solver options. Analysis and interpretation of results.

Fundamentals of heat and mass transfer

Energy transport. Steady and unsteady heat conduction. First Fourier law and its application. Differential energy balance. Heat convection, heat transfer, Newton equation, overall heat transfer. Energy transport by radiation. Energy transport by convection and radiation. Basic rules of heat exchanger designing. Mass transport. Steady and unsteady diffusion. First and second Fick law. Maxwell-Stefan equations for

multicomponent diffusion. Differential mass balance. Exemplary analytical solution of mass balance equation. Estimation of diffusion coefficients. Mass convection, single-phase, two-phase mass transfer. Basics rules of mass exchanger designing. Theoretical one stage exchanger, multi stage exchanger, exchanger with continuous phase contact. Axial dispersion.

Fundamentals of chemical technology

Principles of designing new technologies. Similarity theory and its application. The properties of gases and liquids. The similarity of properties. Calculating methods of the properties of gases and liquids. Chemistry of processes. Stoichiometry of reaction. Calculating the composition of the reaction mixture. Heat of reaction. Chemical affinity. Chemical equilibrium concept and problems. The equilibrium composition of the reaction mixture.

Industry processes and process apparatus, process intensification

Intensification of flow processes in simple systems. Transport of liquids and gases. Pumps characteristics. Pumps systems. Gas compressors. Special pumps and compressors. Vacuum pumps. Introduction to fluid flow in complex systems. Dispersed phase characteristics. Comminution of solids and apparatus. Phase contacting methods: in fixed bed, fluidization and pneumatic conveying. Multiphase flows. Liquid-gas and liquid-liquid flows. Introduction to mechanical phase separation methods. Phase separation methods: sedimentation, filtration, flotation, filtration and centrifuge separation, dust removal. Mixing of solids and liquids. Power consumption. Stirrers and mixing vessels. Assessment of construction functionality and process adequacy of the basic equipment and apparatus types for chemical industry: heat exchangers, evaporators, crystallizers, distillation units and rectification towers, absorbers and adsorbers, extractors and dryers. Life cycle assessment for product, equipment and industrial installation.

Heat transfer process apparatus design

Heat exchangers: principles of operating, construction of exchangers, energetic balances, driving force in heat exchangers: co-current, countercurrent and cross-flow exchangers, wall temperature, calculation of area of heat transfer. Design heat exchange using simulation software ASPEN PLUS. Evaporators: evaporation of solutions, evaporation in industry, energetic and mass balances, multistage evaporation, temperature loses in multistage evaporators.

Process design

Characteristics of simulation software and simulation strategy. Definitions and calculations organization. Basic rules for the selection of thermodynamic models. Introduction to simulation calculations of technological processes. The calculation of the physicochemical properties of the solutions. Selection rules and parameters

of the processes, apparatus, the selection of the reactor and the reaction parameters. The calculation of chemical reactions and reactors. Calculation of the heat exchangers. Criteria for evaluation of the project. Hierarchical method, an example application. Basics of simultaneous methods. Design Heuristics. The use of sensitivity analysis as a tool for selection of parameters of the apparatus.

Chemical reactors

Kinetics of chemical reactions. Reaction rate vs. concentration and temperature. Calculating the composition of the reaction mixture. Chemical reactors - material balance. Periodic reactor. Methods of analysis of kinetic data. Simple and complex reactions in a batch reactor. Continuous stirred tank reactor. Cascade of reactors. Plug-flow reactor. Semi- continuous reactor. Plug-flow with recycling of flux. Comparison of reactors for simple reactions. Comparison of reactors for complex reactions.

Chemical technology

Principles of Green Chemistry. Current trends in chemical technology. Raw materials for chemical and petrochemical industry - reproducible, minerals and fossil. Processing of the basic renewable raw materials. Selected inorganic chemical processes. Processing of coal. Processing of natural gas. Syngas and its utilization in fuel production. Processing of oil. Production of fuels, olefins and aromatics. Selected processes of the large scale industrial synthesis of organic chemicals. Production of methanol, vinyl chloride, styrene, terephthalic acid, ethylene glycol and others.

Engineering thermodynamics

Equations of state of fluids, thermodynamic functions, characteristic processes for non-ideal liquids, thermodynamics of cooling and heating cycles. Equations of state for real solutions, thermodynamic functions for real solutions. Basics of equilibrium in multiphase systems, fugacity, activity, methods of calculation. Phase equilibrium for systems liquid-liquid, liquid-vapor, liquid-solid.

Foreign language

Possible choice: English, French, German or Russian.

Physical education

Athletics. All-purpose development with an emphasis on: strength, speed, jumping ability, endurance, agility, flexibility and dexterity. Basketball. Football. Volleyball. Motor activity with music (possible choice): aerobics, step reebok, Callanetics, exercises with accessories, stretching. Physical education classes conducted at a swimming pool (possible choice): learning and perfecting swimming, for student's unable to swim - teaching two swimming styles: back crawl and classical.

Academic savoir-vivre

Principles and norms of behavior in interpersonal relationships. The origin of the concept of etiquette. Legal and moral norms and customs. The universal rules of the etiquette. Personal culture. Importance of good morals in private and professional life. Stereotypes. Good manners and the image. Classic savoir-vivre rules. Fundamentals of priority and principles of its application. Forms of showing respect. Welcomes - the rules and exceptions. Titles in the academic environment. Personal and business procedures. Social and business precedence. Farewells - rules and exceptions. Wishes and congratulations. Faux pas. Communication etiquette. Standards of good behavior in interpersonal communication. Non-verbal communication. Telephone conversation label. Culture of correspondence. Netiquette. Elegance of public speaking. The importance of clothing in creating a positive image. Savoir vivre and a choice of outfit. General dress rules. Clothing accessories. Fashion and extravagance. The most frequent weaknesses in the selection of individual elements of the outfit. The right outer appearance as part of the positive image.

Social competence

Fundamentals of economics

The model of the market economy. Demand, supply, the balance of the market in the short, medium and long term, the impact of regulated prices on the market, model cobwebs. Consumer choice. The rules of the enterprise. The short run and long run production function in the market, economies of scale, choice of optimal technology. The instruments of cost management in the enterprise, cost function in the long and short term, costs and liquidity. The development of economic systems, economic growth. The importance of the public finance sector. The development of the monetary system, the role of money in the economy. The banking system of the state. The phenomenon of inflation. The labor market, employment policy. International economic relations, the foreign exchange market, balance of payments.

Fundamentals of management

Management as an academic discipline. Company and its environment as an object of management. Management features. Contemporary management problems.

Diploma thesis

Getting to know the professional literature on the subject. Experimental measurements, creation of a computer program or other work related to the use of research tools that are appropriate to the studied area and educational profile. Preparation of the diploma thesis. Diploma exam.

Professional training

Training on safety work and anti-fire regulations in plant/company/institution. Extending of knowledge gained on university in practical way. Introducing to work of plant/company/institution and with their internal procedures. Preparation to job in future.

Diploma seminar

Interpersonal communication: fundamental aspects, creation of credibility and trust. The rules of verbal communication: techniques of argumentation. The role of the voice. Principles of non-verbal communication. The role of the appearance. Public speaking: types, preparation, coping with stress. Selected situations with presentation: exams, defense of the thesis, interview. Scope and subject of the BSc thesis. Gathering of literature data, their selection and evaluation. Discussion on rules of writing a thesis. Discussion on preparing a multimedia presentation. Consultation during thesis preparation. Discussions after multimedia presentation during seminars.

Selectable speciality:

Product design and engineering of pro-ecological processes

Diffusion separation processes

Absorption. Gas-liquid equilibrium. Mass balance of a process and its operating line. Methods of mass exchanger calculation. Distillation and rectification. Liquid-vapor equilibrium for two- and multi-component systems. Simple distillation. Steam distillation. Adjustment of the two-component batch and continuous rectification. Design issues. Extraction in liquid-liquid systems. Basics of physicochemical extraction. Multi-stage extraction. Extraction column for ternary systems. Drying processes. Thermodynamics of drying. Mass and heat transfer in drying processes.

Engineering of powder materials

Interparticle forces in powders: van der Waals, electrostatic and capillary adhesion forces. Phenomenological theories of adhesion: JKR, DMT and Maugis-Dugdal models. Adhesion force measurements methods. Bulk powders and mechanical properties of powder bed. Methods for mechanical properties measurement. Carr and Johanson indices. Cohesion and flowability of powder. Storage of bulk powders; silo design. Industrial processes based on powder properties: mixing, granulation and tableting.

Waste treatment engineering

Wastewater characteristics. Wastewater composition. Effluent disposal. Legislation on waste water treatment. Classification of wastewater treatment methods. Equalization of composition and flow rate. Screening. Bar racks and screens. The process of sedimentation. Grit chambers. Sedimentation tanks. Biological processes - characteristics, kinetics. Basics of modeling biochemical conversions. Removal of organic compounds and nutrients. The reactors used in wastewater treatment plants. Activated sludge method. Technological and technical parameters. Models of processes. Biofilters. Wastewater treatment in natural conditions in the soil environment and the use of plants. Processes: flotation, filtration, coalescence, neutralization, adsorption, coagulation, oxidation, disinfection. Nitrification, denitrification, phosphorus removal (chemical, biological), integrated removal of the C, N and P elements.

Product engineering

Kotler product concept. Basic principles of product design and development. Identifying customer needs. Reverse transformation and forward transformation in product design. Fundamentals of market segmentation. Product positioning. Product design for the environment. Identification of product quality features. Methodology House of Quality in product design. Nanotechnology in product design. Solvents design. Designing of building materials. Design of adhesives. Designing of fibrous materials.

Environmental engineering

Fundamentals of ecology. The environment as a system. Cycles of oxygen, CO_2, and N_2 in nature. Chemical toxic substances in the environment and their biological impact. Pollution. Risks relating to atmosphere, hydrosphere and lithosphere. Control and monitoring systems for the industrial environment. Methods of chemical engineering in removing pollutants from flue gases and natural gas and sewage. Methods of disposal of solid impurities. Groundwater and their protection. Industrial hazards. Environmental risk assessment and industrial risks. Energy production as an important environmental risk factor. Environmental monitoring. Genetically modified organisms (GMOs). Bioethics.

Engineering of the sustainable industrial processes

Introduction to sustainable (environmentally friendly) industrial processes. Thermodynamic basis of sustainable development. Chemical and physical indicators of environmental load. 12 principles of green chemistry. Rules of sustainable industrial process design. Process intensification. Minimization of thermal energy and raw materials consumption through process integration.

3D Computer Aided Design

Dimensioning. Size, shape and position tolerance. Surface roughness marks. Methods of combining parts of machines. Inventor start and basic settings. Inventor 2D modeling possibilities. Examples of application of selected features in Inventor 3D space. Practical exercises of 3D modeling. Fundamentals of stress analysis for a model. Design of chemical equipment element.

Renewable sources of energy and energy-saving technologies

Energy potential of biomass. Biomass combustion, combustion chemistry. Possible scales of the combustion process. Energy crops. Combination of energy crops and sewage treatment plants. Advantages and disadvantages of biogas energy production. Synthesis of biofuels. Use of solar thermal energy. Solar collectors - theoretical foundations, construction, design. Passive Solar Energy Systems. Heat pumps and their use for solar energy. Photovoltaics. Fuel cells. Geothermal sources. Wind energy characteristics. Low temperature heat pumps, heat transformers. Nuclear power. Comparison of traditional and renewable energy sources. Power Generation Models. Economies of scale. Soft and hard technology.

Selected unit operations

Mechanisms of mass transfer. Diffusion equation and its application. Mass balance in liquid-solid system. Mass transfer for fluid flow around a solid particle for small and large values of Reynolds number. Mass transfer and natural convection. Objectives and methods of dissolution process. Kinetics of dissolution. Different methods of dissolution. Objectives and methods of crystallization. Special methods of crystallization. Objectives and methods of membrane processes. Structure and preparation of membranes. Classification of membranes. Applications of membrane processes. Presentation of commercial apparatus and techniques for mass transfer processes. Computing procedures and methods for the typical process of mass transfer.

Selectable speciality:

Processing of polymer materials

Diffusion separation processes

[described in speciality: *Product design and engineering of pro-ecological processes* – see above]

Elements of rheology in polymer processing

Stress, deformation, kinematics of deformation. Rheological equation of state, rigid substance, liquid substance. Definition of viscoelasticity of polymers, mechanical models. Viscosity of polymer during flow. Rheological properties of alloys and solutions of polymers. Practical application of rheology: isothermal flow and non-isothermal flow through channels with different sections; polymer flow in single-screw extruder and double-screw extruder (isothermal, adiabatic and polytropic regime).

Evaluation of practical properties of polymer materials

Basic physical properties of polymeric materials: density, porosity, solubility, moisture content, absorbability. Classification of the polymer materials taking into account methods of processing and the practical applications. Determination of strength properties (static and dynamic) of polymeric materials. Thermal properties and flammability of plastics. Determination of temperature of phase transition (glass transition, melting, crystallization). Testing method of heat resistance. Assessment of thermal resistance under prolonged load. Methods of evaluation of aging and chemical resistance. Determination of electric, magnetic, acoustic, optical properties of polymeric materials. Analysis of polymer morphology.

Fundamentals of CAD/CAE in polymer processing

Methods of 3D-CAD design dedicated to incremental manufacturing systems. 3D-CAD model data processing and preparation of data for the manufacturing process. Using the selected system of incremental prototyping. Postprocessing and finishing works on the prototype. Methods of modeling and processing data for the process of rapid product prototyping.

Modern modification methods of the polymer materials

Chemical modification: block copolymers, alternating and graft copolymers with vinyl and diene copolymers. Thermodynamic conditioning of polymer miscibility. Physical modification, types and properties of polymer fillers, types of fibrous fillers, plasticization of polymeric materials. Nanomaterials obtained by physical

modification. Methods of surface modification of polymeric materials. Application of polymer modification in paint and varnish industry.

Modern polymer technologies

Carbonic polymers, graphene and its analogues. Polycarbines, polyacetylene, topochemical polymerization. Fullerenes and polyfullerenes and their modifications. Supramolecular polymers - charge transfer complexes, inclusion complexes, supramolecular recognition, self-organization of matter. Topological polymers – polycatenanes, polyrotaxanes and polyxarenes, polymers with molecular traces.

Industrial polymer materials

Types of polymer materials used in industry. Classification of polymers by their range of application.

Technology of monomers

Olefinic monomers. Dienes. Vinyl and acrylic monomers. Polyols. Carboxylic acids and their derivatives. Aliphatic and aromatic polyamines. Phenols.

Processing technology of polymer materials

Auxiliaries for plastics processing. Preparation of plastics for processing. Forming treatment. Extrusion and related technologies. Injection and related technologies. Application, spraying. Dipping. Coating. Lamination. Pressing. Rolling and calendering. Foaming. Sintering. Finishing of plastics. Secondary molding. Joining and bending. Surface treatment of products: dyeing, printing, metallization. Chip processing. Improving the surface. Design: Basic tools used in plastics processing. Injection molds for thermoplastics. Application of CAD CAM software in the design. Laboratory: Investigation of the influence of compression molding parameters of thermosetting molds on the properties of moldings. Setting up the thermoplastic injection process. Study of the effect of injection molding parameters of thermoplastics on the strength properties of moldings. Examination of extrusion performance of plastic profiles. Study of the effect of extrusion blowing parameters on the properties of polyolefin films. Polyester-glass composites (laminates). Metal bonding. Determining the optimum rolling time of the rubber blends. Study on the effect of selected parameters on the strength of seams welded from polymeric films. Processing of polychlorovinyl pastes. Galvanic metallization of plastics. Production of plastic products by casting method. Thermoforming.