Faculty of Chemical Technology and Engineering

WEST POMERANIAN UNIVERSITY OF TECHNOLOGY
IN SZCZECIN, POLAND

THE OFFER FOR INTERNATIONAL STUDENTS
FOR THE YEAR 2021/2022
SECOND DEGREE

	Course title	Person responsible for the course	Semester (winter/summer)	ECTS points	Hours
1	ADVANCED OXIDATION PROCESSES IN WATER AND WASTEWATER TREATMENT	Ewelina Kusiak-Nejman	winter/summer	4	60
2	AGITATION AND AGITATED VESSELS	Anna Kiełbus-Rąpała	winter/summer	3	45
3	ANALYSIS OF FOOD CONTAMINANTS	Małgorzata Dzięcioł	winter/summer	2	45
4	ANALYSIS OF WATER AND EFFLUENTS	Sylwia Mozia	winter/summer	6	105
5	APPLIED METROLOGY AND MEASUREMENTS FOR CHEMISTS	Dariusz Moszyński	winter/summer	4	60
6	BASIC OPERATIONS IN CHEMICAL ENGINEERING	Anna Story	summer	3	45
7	BASIC PRINCIPLES AND CALCULATIONS IN CHEMICAL ENGINEERING	Konrad Witkiewicz	winter/summer	4	60
8	BIO-INSPIRED MATERIALS	Mirosława El Fray	winter	3	45
9	BIOMATERIALS	Piotr Sobolewski	summer	2	30
10	BIOPOLYMERS	Piotr Sobolewski	summer	2	30
11	BIOPROCESS ENGINEERING	Agata Markowska-Szczupak	winter/summer	3	45
12	CHEMICAL AND PROCESS ENGINEERING	Halina Murasiewicz	winter/summer	5	75
13	CHEMICAL ENGINEERING DESIGN	Halina Murasiewicz	winter/summer	5	60
14	CHEMICAL ENGINEERING FUNDAMENTALS	Anna Kiełbus-Rąpała	winter/summer	4	60
15	CHEMICAL ENGINEERING PROCESSES IN INDUSTRY	Ewa Ekiert	winter/summer	4	60
16	CHEMICAL ENGINEERING PROCESS SIMULATION USING ASPEN PLUS	Halina Murasiewicz	winter/summer	5	60
17	CHEMICAL PROCESS EQUIPMENT	Halina Murasiewicz	winter/summer	4	60
18	CHEMICAL PROCESSES IN INORGANIC INDUSTRY AND ENVIRONMENTAL ENGINEERING	Sylwia Mozia	winter/summer	3	45
19	CHEMICAL REACTION ENGINEERING	Halina Murasiewicz	winter/summer	4	60
20	CHROMATOGRAPHIC METHODS	Małgorzata Dzięcioł	winter/summer	5	90
21	COLLOID AND INTERFACE CHEMISTRY	Ewa Janus	winter/summer	3	45
22	CORROSION AND ANTICORROSION PROTECTION OF MATERIALS	Krzysztof Kowalczyk	summer	3	45
23	COSMETIC CHEMISTRY	Beata Kołodziej	summer	2	30
24	COSMETIC FORMULATION	Paula Ossowicz	winter/summer	3	45
25	DRYING TECHNIQUES	Konrad Witkiewicz	winter/summer	4	60
26	ELECTRICAL ENGINEERING FOR CHEMISTS	Dariusz Moszyński	winter/summer	3	45
27	ENGINEERING GRAPHICS AND DESIGN	Grzegorz Story	winter/summer	3	45

	Course title	Person responsible for the course	Semester (winter/summer)	ECTS points	Hours
28	ENVIRONMENTAL POLLUTION CONTROL	Halina Murasiewicz	winter/summer	4	60
29	FLUID MECHANICS	Anna Story	summer	4	60
30	FUNDAMENTAL OF PHYSICAL CHEMISTRY	Krzysztof Lubkowski	winter/summer	4	75
31	GAS CLEANING METHODS AND TECHNOLOGIES	Jacek Przepiórski	winter/summer	2	30
32	HEAT TRANSFER	Maciej Konopacki	winter/summer	3	45
33	HETEROGENEOUS CATALYSIS IN INDUSTRY	Dariusz Moszyński	winter/summer	4	60
34	INDUSTRIAL AUTOMATION AND PROCESS CONTROL FOR CHEMISTS	Dariusz Moszyński	winter/summer	3	45
35	INSTRUMENTAL ANALYSIS	Elwira Wróblewska	winter/summer	4	75
36	INTRODUCTION TO ORGANIC SYNTHESIS AND PRODUCTS ANALYSIS	Jacek Sośnicki	winter	5	90
37	INTRODUCTION TO RHEOLOGY	Anna Story	summer	4	45
38	ISOLATION AND CHARACTERIZATION OF NATURAL PRODUCTS FROM PLANTS	Małgorzata Dzięcioł	winter/summer	3	45
39	MACROMOLECULAR CHEMISTRY	Agnieszka Piegat	winter	2	30
40	MASS TRANSFER	Maciej Konopacki	winter/summer	3	45
41	MATERIALS SCIENCE IN CHEMICAL ENGINEERING	Rafal Pelka	winter/summer	3	45
42	MEMBRANE PROCESSES	Sylwia Mozia	winter/summer	1	15
43	METHODS OF ORGANIC COMPOUNDS IDENTIFICATION	Elwira Wróblewska	winter/summer	3	45
44	MODELING AND SIMULATION IN CHEMICAL ENGINEERING	Anna Story	summer	4	60
45	MULTIPHASE FLOWS	Anna Kiełbus-Rąpała	winter/summer	3	45
46	NANOPARTICLES AND ENVIRONMENT	Beata Tryba	winter/summer	2	15
47	ORGANIC COATINGS	Krzysztof Kowalczyk	summer	4	60
48	PARTICULATE TECHNOLOGY	Anna Story	summer	3	45
49	PHARMACEUTICAL CHEMISTRY	Paula Ossowicz	winter/summer	4	60
50	PHOTOCATALYSIS FOR ENVIRONMENTAL APPLICATION	Ewelina Kusiak-Nejman	winter/summer	4	60
51	PHYSICAL CHEMISTRY OF SURFACES	Dariusz Moszyński	winter/summer	3	45
52	POLYMER CHEMISTRY	Mirosława El Fray		2	30
53	POLYMER COMPOSITES	Krzysztof Kowalczyk	winter	4	60
54	POLYMER TESTING	Krzysztof Kowalczyk	summer	4	60
55	PRINCIPLES OF ANALYTICAL CHEMISTRY	Zbigniew Rozwadowski	summer	3	45

	Course title	Person responsible for the course	Semester (winter/summer)	ECTS points	Hours
56	PRINCIPLES OF BIOCHEMISTRY	Agata Markowska-Szczupak	winter/summer	3	30
57	PRINCIPLES OF ORGANIC CHEMISTRY	Jacek Sośnicki	winter	4	75
58	PROCESS DYNAMICS	Maciej Konopacki	winter/summer	4	60
59	PROCESS SAFETY ENGINEERING	Halina Murasiewicz	winter/summer	4	60
60	PROPERTIES AND CHARACTERIZATION OF POLYMERIC MATERIALS	Agnieszka Piegat	summer	2	30
61	PROPERTIES OF RESERVOIR FLUIDS	Konrad Witkiewicz	winter/summer	4	60
62	QUALITY ENGINEERING	Jolanta Szoplik	winter/summer	4	60
63	RAW MATERIALS FOR THE COSMETICS PRODUCTS	Paula Ossowicz	winter/summer	2	30
64	RENEWABLE ENERGY SOURCES	Halina Murasiewicz	winter/summer	4	60
65	RESEARCH PROJECT IN BIOLOGICALLY ACTIVE COMPOUNDS	Małgorzata Dzięcioł	winter/summer	8	135
66	RESEARCH PROJECT IN CARBON SPHERES PRODUCTION	Iwona Pełech	winter/summer	9	135
67	RESEARCH PROJECT IN CHEMICAL ENGINEERING	Halina Murasiewicz	winter/summer	8	120
68	RESEARCH PROJECT IN GREEN CHEMISTRY	Beata Kołodziej	winter/summer	12	240
69	RESEARCH PROJECT IN POLYMER MATERIALS	Beata Schmidt	winter/summer	8	90
70	RESEARCH PROJECT ON MIXING OF MULTIPHASE SYSTEMS	Anna Kiełbus-Rąpała	winter/summer	15	300
71	RESEARCH PROJECT ON POLYMERIC BIOMATERIALS	Agnieszka Piegat	summer	4	60
72	SELECTED ISSUES IN POLYMER CHEMISTRY	Beata Schmidt	winter/summer	2	30
73	SELF-HEALING MATERIALS FOR AIR PURIFICATION	Ewelina Kusiak-Nejman	winter/summer	4	60
74	SEPARATION PROCESSES	Bogdan Ambrożek	winter/summer	4	60
75	SPECIAL METHODS OF SEPARATION	Anna Kiełbus-Rąpała	winter/summer	4	60
76	SPECTROSCOPIC METHODS	Elwira Wróblewska	winter/summer	4	75
77	STATISTICAL METHODS IN ENGINEERING	Anna Story	summer	3	45
78	SURFACTANTS CHEMISTRY AND ANALYSIS	Paula Ossowicz	winter/summer	3	45
79	TECHNICAL AND INDUSTRIAL ANALYSIS	Ewa Ekiert	winter/summer	4	50
80	TECHNICAL THERMODYNAMICS	Konrad Witkiewicz	winter	6	90
81	TECHNOLOGIES IN ENVIRONMENTAL PROTECTION	Małgorzata Dzięcioł		5	75
82	TESTING METHODS OF INORGANIC PRODUCTS	Dariusz Moszyński	winter/summer	5	90
83	THERMODYNAMICS OF PHASE AND REACTION EQUILIBRIA	Konrad Witkiewicz	winter/summer	4	60

	Course title	Person responsible for the course	Semester (winter/summer)	ECTS points	Hours
84	THERMODYNAMICS WITH CHEMICAL ENGINEERING APPLICATIONS	Konrad Witkiewicz	winter/summer	4	60
85	TRANSPORT PHENOMENA	Halina Murasiewicz	winter/summer	4	60

Course title	ADVANCED OXIDATION PROCESSES IN WATER AND WASTEWATER TREATMENT		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Ewelina Kusiak-Nejman	**E-mail address to the person**	Ewelina.Kusiak@zut.edu.pl
Course code (if applicable)	WTiICh-2-01	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The course is aimed at giving an overview of Advanced Oxidation Processes for water and wastewater treatment. Student will be able to define basic processes, including water purification, oxidation processes, etc. Student will be able to know the mechanisms of different AOPs processes, including Fenton and photo-Fenton, photocatalytic processes, electrooxidation, etc. Student will be able to know the mechanism of microorganisms inactivation with application of AOPs methods.		
Entry requirements	The basic knowledge of basic safety rules The basic knowledge of Advanced Oxidation Processes		
Course contents	Fenton and photo-Fenton processes for organic compounds degradation from water UV-assisted AOPs processes for water puricitation Photocatalytic decomposition of organic pollutants from water and wastewater Photocatalytic disinfection of water Ozonation for pollutants and microbials oxidation method 1. Introduction to Advanced Oxidation Processes Materials in Advanced Oxidation Processes Fenton and photo-Fenton processes - principles and mechanisms Photocatalysis - phenomena and mechanism UV-assisted AOPs processes Solar-irradiated AOPs processes Electrochemical oxidation as AOPs process Application of AOPs processes in water and wastewater treatment technology Disinfection of water and wastewater utilizing AOPs processes Final test		
Assessment methods	Lectures Discussion with the teacher Final written test - lectures Preparation of laboratory reports - laboratory classes A test to check preparation for laboratory activities - laboratory classes		
Recommended readings	1. Yang Deng, Renzun Zhao, Advanced Oxidation Processes (AOPs) in Wastewater Treatment, Current Pollution Reports, 2015, 1(3), 167-176 2. Mihaela I. Stefan (Ed.), Advanced Oxidation Processes for Water Treatment: Fundamentals and Applications, IWA Publishing, 2017, https://doi.org/10.2166/9781780407197 3. Charles R. Gilmour, Water Treatment Using Adv eatment Using Advanced Oxidation Pr anced Oxidation Processes: ocesses: Application Perspectives, 2012, http://ir.lib.uwo.ca/cgi/viewcontent.cgi?article=2115&context=etd 4. Ana R. Ribeiro, Olga C.Nunes, Manuel F.R. Pereira, Adrián M.T.Silva, An overview on the advanced oxidation processes applied for the treatment of water pollutants defined in the recently launched Directive 2013/39/EU, Environment International, 2015, 75, pages 33-51		
Knowledge	As a result, the student should be able to define basic concepts related to advanced oxidation processes. As a result, the student should be able to explain the phenomena of the advanced oxidation processes. As a result of the classes, the student should be able to list the types of processes included in the advanced oxidation processes. As a result of the classes, the student should be able to expalin the mechanisms of presented advanced oxidation processes. As a result of the classes, the student should be able to explain the mechanisms of inactivation of microorganisms utilizing the advanced oxidation processes. As a result, the student should be able to list the materials related to advanced oxidation processes.		
Skills	As a result of the classes, the student should know how to interpret the results of degradation processes. As a result of the classes, the student should know how to calculate the efficiency of the degradation of contaminants utilizing various AOPs. As a result of the classes, the student should know how to conduct the experiments using AOPs. As a result of the classes, the student should know how to prepare laboratory reports containing results and conclusions.		

Other social competences	As a result of the conducted classes, the student will acquire the following attitudes: caring for the environment, openness to changes related to the water contamination, acting in accordance with the rules of ethics, awareness the results of water contamination as a global aspect.

Course title	AGITATION AND AGITATED VESSELS		
Level of course	second cycle		
Teaching method	laboratory course / project course / lecture		
Person responsible for the course	Anna Kiełbus-Rąpała	**E-mail address to the person**	Anna.Kielbus-Rapala@zut.edu.pl
Course code (if applicable)	WTiICh-2-02	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	The course aims to give a general introduction to the theory and practice of agitation and agitated vessels		
Entry requirements	Chemical engineering fundamentals		
Course contents	Power consumption Producing of gas-liquid system in an agitated vessel Mixing time in an agitated vessel Mass transfer in gas-liquid system in an agitated vessel Mass transfer in mechanically agitated solid-liquid system Project of the agitated vessel used to chosen mixing operation (mixing operation: homogenization or heat transfer or mass transfer in a liquid or multiphase systems); engineering calculation of the agitated vessel geometry; engineering calculations of the homogenization or heat and mass transfer processes Agitation of fluids as important unit operation (homogenization of fluids; intensification of heat transfer process; intensification of mass transfer process; mixing with chemical reaction) Mixing equipment (vessels; impellers; baffles; geometry of the agitated vessel; standard geometrical parameters of the agitated vessel; types of the impellers; location of the impeller shaft in the vessel (central, eccentric, side-entering); types of the baffles (planar of full length, short baffles, tubular baffles); types of the heating surfaces areas (jackets, helical coils, tubular vertical coils); static mixers Rules used for the project of the agitated vessels step by step (vessel shape, vessel bottom, heating/cooling surfaces, insulation, impellers, baffles, legs, platforms, seals, shaft bearing, lids, drives, metering ports, sensors and probes, gas supply (gas spargers) Power consumption (power characteristics Ne = f(Re) for laminar, transitional and turbulent regime of the fluid flow; definition of power number Ne; definition of Reynolds number Re for mixing process; an effect of the baffles on the power characteristics; values of the Ne number for different impellers and turbulent range of the fluid flow) Liquid homogenization; mixing time (definition; mixing time measurement; experimental techniques; comparing of mixing time at equal power consumption) Heat transfer in agitated vessels (methods for measuring of mean and local heat transfer coefficients (thermal and electrochemical methods); Nusselt equation (definition of Nusselt number Nu, Prandtl number Pr, coefficient C); an effect of the agitated vessel geometry and impeller type on the heat transfer coefficient; efficiency of heat transfer process (modified Re number, coefficient K); idea of mathematical modeling of local heat transfer coefficient; idea of numerical modeling of heat transfer process Mass transfer in agitated vessels (methods of mass transfer coefficient measurements; correlations for mass transfer coefficient) Mechanically agitated gas – liquid, solid – liquid, liquid – liquid and gas – solid – liquid systems (dispersions; suspensions; emulsions); maps of the gas – liquid dispersions; suspension of floating particles; minimum (critical) agitator speeds; an effect of the impeller type, baffles type and geometrical parameters of the agitated vessel on the producing of the heterogeneous systems; gas hold-up; superficial gas velocity, interfacial area; Sauter mean diameter Mixing with chemical reaction Mixing of particulate solids		
Assessment methods	lecture illustrated by Power Point presentation laboratory exercises projects method lectures and laboratory - written test completion of the project based on the correctly performed computations		
Recommended readings	1. Harnby N., Edwards M.F., Nienow A.W., Mixing in the Process Industries, Butterworth-Heinemann, Oxford, 1997 2. Mixing Equipment (Impeller Type), AIChE Equipment Testing Procedure, 3rd Edition, New York, 2001, ISBN 0-8169-0836-2 3. Nagata S., Mixing. Principles and Applications, Halsted Press, New York, 1975 4. Paul E.L., Atiemo-Obeng V.A, Kresta S.M; (Ed.), Handbook of Industrial Mixing, John Wiley & Sons, Inc., New York, 2004 5. Tatterson G.B., Fluid Mixing and Gas Dispersion in Agitated Tanks, McGraw-Hill, Inc., New York, 1991		
Knowledge	to provide a detailed theoretical knowledge within the framework of the agitation processes		
Skills	to provide practical kowledge within the framework of the agitation and agitated vessels		
Other social competences	student understands the needs of continuous training and development in the field of the agitations problems		

Course title	ANALYSIS OF FOOD CONTAMINANTS		
Level of course	second cycle		
Teaching method	laboratory course		
Person responsible for the course	Małgorzata Dzięcioł	**E-mail address to the person**	Malgorzata.Dzieciol@zut.edu.pl
Course code (if applicable)	WTiICh-2-03	**ECTS points**	2
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Knowledge about typical contaminants generated naturally in food and brought from environment and practical skills in their analysis.		
Entry requirements	Basics of analytical chemistry		
Course contents	Natural contaminants present in foods. Natural toxicants generated in food during spoilage processes. Determination of ethanol and methanol content in beverages. Changes in plant oils at high temperature. Products of fats oxidation. Environmental toxicants (pesticides, pharmaceuticals, industrial contaminants). Pesticide residues in food. Contaminants of drinking water. Analysis of food adulteration. Test		
Assessment methods	Laboratory Individual work with literature Evaluation of working in the laboratory Evaluation of written reports Test		
Recommended readings	1. ed. W.M. Dąbrowski, Z.E. Sikorski, Toxins in Food, CRC Press, Boca Raton, 2005 2. T. P. Coultate, Food: the Chemistry of its Components, RSC, Cambridge, 2009 3. ed. T. Reemtsma, M. Jekel, Organic pollutants in the water cycle, Wiley-VCH, Weinheim, 2006		
Knowledge	Student will be able to explain sources of different food contaminants.		
Skills	Student will be able to perform analysis of selected food contaminants and examine adulteration of food. Student will be able to collect and organize data from literature.		
Other social competences	Student is aware of the impact of food contaminants on consumer health.		

Course title	ANALYSIS OF WATER AND EFFLUENTS		
Level of course	second cycle		
Teaching method	lecturing course / laboratory course / lecture		
Person responsible for the course	Sylwia Mozia	**E-mail address to the person**	Sylwia.Mozia@zut.edu.pl
Course code (if applicable)	WTiICh-2-04	**ECTS points**	6
Semester	winter/summer	**Language of instruction**	english
Hours per week	7	**Hours per semester**	105
Objectives of the course	Student will get theoretical knowledge on chemical composition of natural waters, water and wastewater treatment processes, drinking water quality standards and wastewater quality standards, methods of preservation and analysis of water and wastewater samples. Student will get practical skills in the area of analysis of water and wastewater parameters.		
Entry requirements	Water and wastewater treatment, analytical chemistry		
Course contents	Calculation of solutions concentrations, pH, hardness, alkalinity and acidity of natural waters, corrosivity, BOD. Regulations concerning drinking water quality. Determination of PO43-, N-NO3-, N-NH4+ and dissolved oxygen concentrations, determination of COD-Cr, COD-Mn, TOC, alkalinity, acidity, hardness, color, turbidity and pH of water, evaluation of water corrosivity. Characteristics of surface water and groundwater. Classification of waters. Regulations concerning drinking water quality. Characteristics of municipal wastewater and selected industrial effluents. Wastewater quality standards. Aims and ranges of water and wastewater analysis. Fundamentals of analysis of water and wastewater. Background of sampling. Sample stabilization and safe keeping. Physical and chemical indicators of water and wastewater contamination. Indicators of bacteriological contamination of water. Methods of analysis of water and wastewater.		
Assessment methods	lecture workshop laboratory Lecture: written exam Workshop: class test/grade Laboratory: report, class test/grade		
Recommended readings	1. Ed. Leo M.L. Nollet, Handbook of Water Analysis, CRC Press LLC, USA, 2007, Second Edition 2. K. Kaur, Handbook of water and wastewater analysis, Atlantic Publishers & Distributors (P) Ltd., 2007 3. irk-Othmer, Chemical Technology and the Environment, Vol. 1 and 2, 2007 4. ed. O. Hutzinger, Handbook of Environmental Chemistry, Vol.5, part A, Water Pollution, Springer-Verlag, 1991 5. B.J. Alloway, D.C. Ayres, Chemical Principles of Environmental pollution, Blackie Academic & Professional, 1993 6. Water treatment, Plant Design, American Water Works Association, McGraw, 1998, 3th Edition 7. W.J. Masschelein, Unit Processes in Drinking Water Treatment, Marcel Dekker Inc., 1992		
Knowledge	At the completion of this course, students will be able to: - Understand fundamental water chemistry. - Learn the parameters that characterize the constituents found in potable water and wastewater. - Comprehend water/wastewater quality data. - Characterize water and wastewater.		
Skills	At the completion of this course, students will be able to plan and carry out experiments for analysis of water and wastewater quality, collect experimental data, analyze and interpret results, write technical reports and give presentations.		
Other social competences	Student understands the needs of continuous training and development in the field of analysis of water and effluents		

Course title	APPLIED METROLOGY AND MEASUREMENTS FOR CHEMISTS		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Dariusz Moszyński	**E-mail address to the person**	Dariusz.Moszynski@zut.edu.pl
Course code (if applicable)	WTiICh-2-05	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	To learn the students to know principles of metrology To learn how to choose the proper measurement tools To learn the methods of measurement data evaluation To let the students know standard methods for measurement of physical properties		
Entry requirements	Math Physics Electrical engineering		
Course contents	Data evaluation for laboratory testing Basic electrical measurements Principal methods of temperature measurement Weight and density measurements Pressure and flow measurements Principles of metrology Data analysis Measurements of physical dimentions Mesurement of weight and density Temperature measurements Electrical measurements Measurements of flow and level		
Assessment methods	Lecture Case analysis Laboratory Exam Activity evaluation		
Recommended readings	1. Bucher, Jay L., Metrology Handbook (2nd Edition), American Society for Quality (ASQ), 2012 2. Raghavendra, N.V.; Krishnamurthy, L., Engineering Metrology and Measurements, Oxford University Press, 2013		
Knowledge	Student knows the principles of experimental data assessment		
Skills	Student is able to chose and perform the basic measurement experiments		
Other social competences	Student is competent to perform simple measurements		

Course title	BASIC OPERATIONS IN CHEMICAL ENGINEERING		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Anna Story	**E-mail address to the person**	Anna.Story@zut.edu.pl
Course code (if applicable)	WTiICh-2-06	**ECTS points**	3
Semester	summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Understanding the basics of basic operations in the area of fluid mechanics and their importance in constructing various industrial processes. Distinguishing various basic operations and understanding the basics of their classification. Theoretical and practical preparation enabling students to apply the acquired knowledge and skills in professional and specialist courses.		
Entry requirements	Chemical engineering fundamentals Applied Mathematics		
Course contents	A total of 5 laboratory exercises will be carried out with a total teaching load of 15 hours. Possible laboratory: determination of particle size by sieving, determination of the operating parameters of a stirring and mixing system: power characteristic and mixing time, sedimentation, clarification of liquids, pneumatic transport and gas cleaning. Unit operations with fluids (fluid transport, energy relations, measures of fluid flow) Unit operations with solids (storage and mechanical transportation of solids, reduction of size, the sieving operation, ideal sieves and real sieves) Mixing and mixing tanks (mixing equipment, calculation of the required power, evaluation of the power of different agitation systems, mixing time determination, mixing of liquids, mixing of multiphase systems) Displacement of solids in fluids (movement of particles in a fluid, definition of sedimentation and its characteristics, flocculation and coagulation, sedimentation equipment, hydraulic classification, wet classification and screening, types of classifiers) Movement of fluids between solids (circulation of fluids through porous beds, pneumatic and hydraulic transport, filtration) Unit membrane separation operations (microfiltration, ultrafiltration, reverse osmosis, electrodialysis) Unit operations with heat transfer (heat transfer fundamentals, heat exchangers, operations with vapor-liquid transfer, types of evaporators, single acting evaporators, multiple effect evaporators) Unit operations with mass transfer (general aspects of mass transfer, basis of unit mass transfer operations, solid-liquid extraction, liquid-liquid extraction) Written final test		
Assessment methods	Activating methods: lecture illustrated by multimedia presentation and didactic discussion Practical methods: laboratory exercises Lectures - written final test Laboratory - individual report after each laboratory		
Recommended readings	1. John J. McKetta Jr, Unit Operations Handbook: Volume 1, CRC Press, New York, 1993, ISBN 9780824786694 2. John J. McKetta Jr, Unit Operations Handbook: Volume 2, CRC Press, New York, 1993, ISBN 9780824786700 3. McCabe Warren L., Unit Operations of Chemical Engineering, McGraw-Hill, 2005, ISBN 9780071247108 4. Geankoplis Christie John, Transport Processes and Separation Process Principles (Includes Unit Operations), Pearson Education Limited, 2013, 4th Edition, ISBN 9781292026022		
Knowledge	Students will acquire detailed theoretical knowledge on many aspects within the framework of the basic operations in chemical engineering		
Skills	Students will acquire practical knowledge on many aspects within the framework of the basic operations in chemical engineering		
Other social competences	Students have the ability to solving and analyzing processes in the field of basic operations in chemical engineering. Students understand the needs of continuous training and development in the field of basic operations in chemical engineering		

Course title	BASIC PRINCIPLES AND CALCULATIONS IN CHEMICAL ENGINEERING		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Konrad Witkiewicz	**E-mail address to the person**	Konrad.Witkiewicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-07	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The student will be able to: 1. Explain the basic elements of engineering calculations. 2. Demonstrate basic knowledge of material and energy balances. Student will be able to solve typical problems associated with simplified process modeling in chemical engineering.		
Entry requirements	Basic knowledge of mathematics.		
Course contents	Solving problems presented during lectures. Introduction to chemical engineering calculations: units and dimensions, conventions in methods of analysis and measurement, chemical equation and stoichiometry. Problem solving: techniques of problem solving, computer-based tools, sources of data. Material balances without/with chemical reactions, solving material balance problems involving multiple subsystems, recycle, bypass, and purge calculations. Gases, vapors, liquids, and solids: ideal gas law calculations, real gas relationships, vapor pressure and liquids, vapor-liquid equilibria for multicomponent systems, partial saturation and humidity, material balances involving condensation and vaporization. Energy balances: concepts and units, calculation of enthalpy changes, application of the general energy balance without/with chemical reactions, reversible processes and the mechanical energy balance, heats of solution and mixing, humidity charts and their use. Solving simultaneous material and energy balances: analyzing the degree of freedom in a steady-state process. Unsteady-state material and energy balances.		
Assessment methods	Lecture Classes Lecture: written exam Classes: written test		
Recommended readings	1. D.M. Himmelblau, Basic Principles and Calculations in Chemical Engineering, Prentice Hall International (UK) Limited, London, 1996 2. W.L. Luyben, L.A. Wenzel, Chemical Process Analysis: Mass and Energy Balances, Int. Ser. in Phys. & Chem. Eng. Sci., Prentice Hall, Englewood Cliffs, NJ, 1988 3. E.I., Shaheen, Basic Practice of Chemical Engineering, Houghton Mifflin, Boston, 1984, 2nd ed.		
Knowledge	Student demonstrates basic knowledge of engineering calculations.		
Skills	Student can solve typical problems associated with process modeling in chemical engineering.		
Other social competences	Student understands the need for continuous training and development in the field of engineering calculations.		

Course title	BIO-INSPIRED MATERIALS		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Mirosława El Fray	**E-mail address to the person**	Miroslawa.ElFray@zut.edu.pl
Course code (if applicable)	WTiICh-2-08	**ECTS points**	3
Semester	winter	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	This course is aimed at giving introduction to the field of bio-inspired materials where natural processes and phenomena are used by engineers to design functional materials. Student will be able to defined basic terms related to biologically inspired materials and structires, will be able to work in a group and will be able to broaden her/his knowledge in the field.		
Entry requirements	none		
Course contents	Literature review on study subject, including research papers Design, preparation and characterization of bio-inspired materials (functional polymer or composite) with biomimetic functionalities Preparation of written report and presentation of the final work Basic definitions used in bio-inspired design of materials: biomimetic and bionics Molecular design of biological and nanomaterials Multifinctional materials: gradient and hierarchical structures Functional surfaces in biology: self-cleaning, self-adhesion Biological materials in engineering design and mechanisms Artificial muscles using electroactive polymers Artificial replacement of human tissues and bones		
Assessment methods	lecture project examination written report and presentation		
Recommended readings	1. Bar-Cohen Y., Biomimetics Biologically Inspired Technologies, CRC Taylor & Francis, New York, 2006 2. Ratner B.R., Biomaterials Science, Elsevier, New York, 2004		
Knowledge	To provide a theoretical knowledge in the field of bio-inspired materials and structures		
Skills	To provide a practical knowledge in the field of bio-inspired materials and structres, the principle designs and relationships		
Other social competences	To provide competences necessary to understand design principles in engineering materials inspired by nature		

Course title	BIOMATERIALS		
Level of course	second cycle		
Teaching method	lecture		
Person responsible for the course	Piotr Sobolewski	**E-mail address to the person**	psobolewski@zut.edu.pl
Course code (if applicable)	WTiICh-2-09	**ECTS points**	2
Semester	summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	Define important keywords and concepts Describe the interactions between (bio)materials and blood. Describe the host response to a (bio)material. Discuss material-related design considerations for a medical device/implant.		
Entry requirements	Basic understanding of biology and chemistry. Upper level English: reading and speaking.		
Course contents	Introduction and definitions Case study: cardiac catheters Blood-biomaterial contact Host response Surfaces and modification Degradable materials and mechanisms of degradation Drug delivery Select topics and case studies		
Assessment methods	Lecture Presentation		
Recommended readings	1. Buddy Ratner et al, Biomaterials Science, Academic Press		
Knowledge	Define important keywords and concepts		
Skills	Describe the interactions between (bio)materials and blood. Describe the host response to a (bio)material. Discuss material-related design considerations for a medical device/implant.		
Other social competences	Will be capable of independent study and presenting a biomaterial system.		

Course title	BIOPOLYMERS		
Level of course	second cycle		
Teaching method	lecture		
Person responsible for the course	Piotr Sobolewski	**E-mail address to the person**	psobolewski@zut.edu.pl
Course code (if applicable)	WTiICh-2-10	**ECTS points**	2
Semester	summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	Define important keywords and concepts Explain the difference between biopolymers and bio-based polymers Describe the main classes of biopolymers, including key structural and chemical features Discuss specific applications of biopolymers, including key features		
Entry requirements	Basic understanding of biology and chemistry. Upper level English: reading and speaking.		
Course contents	Introduction and definitions Nucleic acids Proteins Polysacchrides Extracellular matrix Aliphatic polyesters Latex and natural rubber Bio-based polymers Degradation and biodegradation Select topics and case studies		
Assessment methods	Lecture Presentation		
Recommended readings	1. David Kaplan, Biopolymers from Renewable Resources, Springer		
Knowledge	Define important keywords and concepts		
Skills	Explain the difference between biopolymers and bio-based polymers Describe the main classes of biopolymers, including key chemical and structural features Discuss specific applications of biopolymers, including key features		
Other social competences	Will be capable of independent study and presenting a biopolymer system.		

Course title	BIOPROCESS ENGINEERING		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Agata Markowska-Szczupak	**E-mail address to the person**	Agata.Markowska@zut.edu.pl
Course code (if applicable)	WTiICh-2-11	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	The course aims to give a general introduction to the theory of bioprocess engineering.		
Entry requirements	introduction to the chemical and process engineering		
Course contents	Project calculations for the bioprocess occuring in a given type of multiphase bioreactor (multistage slurry reactor, immobilized biocatylytic reactor, enzymatic membrane reactor, biofilm reactor or flocculation bioreactor Introductory Remarks: Biotechnology and bioprocess engineering; Up-stream engineering; Bioreactor engineering; Down-stream engineering An overview of biological basics of bioprocess engineering: Enzymes; Cells; Major metabolic pathways; The grow of cells Traditional industrial bioprocesses; Bioethanol; Biogas; Wine production; Manufacture of yeast; Single-cell proteins; Copper bioleaching; Penicilin production Sterilization of process fluids Engineering principles for bioprocesses; Momentum, mass and heat transfer in bioreactors Operating considerations for bioreactors; Types of bioreactors; Selection, scale-up; operations and control of bioreactors Recovery and purification of bioproducts; Finishing steps of purification; Integration of reaction and separation Instrumentation and control Nonconventional bioprocesses		
Assessment methods	lecture illustrated by Power Point presentation projects method written test completion of the project based on the correctly performed project computations		
Recommended readings	1. Cabral J.M.S., Mota M., Tramper J. (Eds), Multiphase Bioreactor Design, Taylor and Francis, London, New York, 2001 2. Doran P.M., Bioprocess Engineering Principles, Academic Press, London, 1995 3. Dutta R., Fundamentals of Biochemical Engineering, Springer, Berlin, 2008 4. Flickinger M.C., Drew S.W., Encyclopedia of Bioprocess Technology: Fermentation, Biocatalysis, and Bioseparation, Wiley, New York, 1999 5. Lydersen B.K., D'Elia N.A., Nelson K.L., Bioprocess Engineering, John Wiley & Sons, Inc., New York, 1994 6. Shuler M.L., Kargi F., Bioprocess Engineering: Basic Concepts, Prentice Hall, New Jersey, 2002 7. Simpson R., Sastry S.K., Chemical and Bioprocess Engineering. Fundamental Concepts for First-Year Students, Springer, New York, 2013 8. Van't Riet K., Tramper J., Basic Bioreactor Design, Marcel Dekker Inc., New York, 1991		
Knowledge	to give a detailed knowledge about bioprocess engineering		
Skills	student has ability to calculate and solve different practical problems on bioprocess engineering		
Other social competences	student understands the needs of continuous training and development in the field of bioprocess engineering		

Course title	CHEMICAL AND PROCESS ENGINEERING		
Level of course	second cycle		
Teaching method	laboratory course		
Person responsible for the course	Halina Murasiewicz	**E-mail address to the person**	Halina.Murasiewicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-12	**ECTS points**	5
Semester	winter/summer	**Language of instruction**	english
Hours per week	5	**Hours per semester**	75
Objectives of the course	Apply process principles learnt in other chemical engineering courses to practical situations Identify and analyse the fundamental physical parameters of an experimental system Write technical reports Perform statistical analysis on data and conduct statistically designed experiments Demonstrate laboratory and analytical skills, safety awareness and organisational skills Demonstrate skills with numerical methods and computing applications		
Entry requirements	Fundamentals of mathematics. Fundamentals of chemical engineering		
Course contents	Comprises experiments related to various aspects reletaing with chemical engineering: measurment of density, viscosity (rhelogy), ph, reflacting index, interfacial tension, mixing process, formulating of two phase system, sedimentation process, measurment techniques used in flow, numerical simulation of flow and process. After successfully conducting an experiment, the students need to write a well formatted technical report. In addition, the course will introduce students to numerical methods for solving typical chemical engineering problems. It also introduces the students to the use of spreadsheets to solve chemical engineering design and process problems.		
Assessment methods	activating methods: didactic discussion practical methods - calculation, design, numerical/simulation study Lab Report (Individual) after each labratory written final test		
Recommended readings	1. Thomas Ch. E., Process technology equipment and systems, Cengage Learning, Stamford, 2015 2. K. Walters, An Introduction to Rheology, Elsevier Science, 1989 3. Howard A. Barnes, A Handbook of Elementary Rheology, University of Wales, Institute of Non-Newtonian Fluid Mechanics, 2000 4. McCabe W.L., Smith J.C., Harriott P., Unit Operations of Chemical Engineering, McGraw-Hill, New York, 2005		
Knowledge	The student will be able to measure a physcial properties of liquid, solid and gas, identify the various types of measurment equipments used in the chemical engineering and use commercial software to analyze data and simulate the process.		
Skills	The student will be able to apply knowledge of measurement techniques to identify physical properties and solve chemical engineering problems.		
Other social competences	Student will be began to prepare for a role as a professional chemical engineer in industry or academia		

Course title	CHEMICAL ENGINEERING DESIGN		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Halina Murasiewicz	**E-mail address to the person**	Halina.Murasiewicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-13	**ECTS points**	5
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The student will be able to: 1.Apply knowledge of chemical engineering fundamentals to identify and solve chemical engineering design problems. 2.Perform step-by-step design of chemical engineering processes. 3.Use of Aspen Plus for chemical engineering design.		
Entry requirements	Fundamentals of chemical engineering		
Course contents	Project of the selected equipment in ASPEN Plus Introduction to design. Design information. Physical properties of chemical compounds. Materials of Construction. Costing. Mechanical design of process equipment. Flow-sheeting. Material and energy balances. Energy utilization. Piping and instrumentation. Equipment selection, specification and design: separation columns, heat-transfer equipment. Aspen simulation. Plant location and site selection. Environmental considerations. Safety and loss prevention.		
Assessment methods	Lecture illustrated by Power Point presentation and computer simulation Project Periodic assessment of student achievement Lecture: exam at the end of the semester Project: assessment of project		
Recommended readings	1. Sinnott R.K., Coulson & Richardson's Chemical Engineering, Vol. 6: Chemical Engineering Design, Butterworth-Heinemann, Oxford, 2003 2. Luyben W.L., Distillation design and control using Aspen simulation, Wiley, New York, 2006		
Knowledge	The student will be able to demonstrate basic knowledge of chemical engineering design problems.		
Skills	The student will be able to apply knowledge of chemical engineering fundamentals to identify and solve chemical engineering design problems.		
Other social competences	The student will be able to use of Aspen Plus for chemical engineering design.		

Course title	CHEMICAL ENGINEERING FUNDAMENTALS		
Level of course	second cycle		
Teaching method	lecturing course / laboratory course / lecture		
Person responsible for the course	Anna Kiełbus-Rąpała	**E-mail address to the person**	Anna.Kielbus-Rapala@zut.edu.pl
Course code (if applicable)	WTiICh-2-14	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The course aims to give a general introduction to the chemical engineering		
Entry requirements	Fundamentals of physics		
Course contents	Basic units of International System of Units Calculations of the basic physical properties for the single and multiphases systems. Concentration of the component in the multicomponent systems Pressure drop in a pipeline and pipeline network Calculations of the particles sedimentation Calculations for the filtration operation Heat transfer calculations. Heat transfer coefficient; heat transfer area; driving difference of temperature; heat exchangers Mass transfer calculations. Mass transfer coefficients; driving difference of concentration; mass transfer area; mass exchangers Destilation and rectification. mass balances; equations of the operating lines; number of the plates in a column Calculations for the others mass transfer processes Fluid flow measurements Rheological properties of the non_Newtonian fluid Process characteristics of the absorption column Fluid flow in a pipeline network Process characteristics of the air-lift reactor Introduction. Units and dimensions. International System of Units. Flow of fluids. Energy and momentum balance. The boundary layer theory. Flow in pipes and chanels. Flow of compressible fluids. Flow of multiphase mixtures. Pumping of fluids. Flow measurement. Pressure measurement. Pressure and flow measuring devices Unit operations of chemical and process engineering. Mixing of liquids. Motion of particles in a fluid. Sedimentation of paricles. Filtration of liquid. Separation. Fluidization Heat transfer. Rate of heat transfer. Heat transfer coefficient. Overall heat transfer coefficient. Temperature profiles. Heat transfer area. Types of the heat exchangers. Mass transfer. The mechanism of absorption. Concentration profile for absorbed component A. Rate of absorption. Driving forces in the gas and liquid phase. film coefficient of mass transfer in absorption process. Overall coefficient of mass transfer. Absorption of gases. Packed columns Distillation. Vapour-liquid equilibrium. Temperature compositions diagrams. Vapour composition as a function of liquid composition at constant pressure. Partial pressures and Dalton's, Raoult's and Henry's laws The fractionating column. The fractionating process. Mass and heat balances. Calculation of plates number for a distillation column. The methods used to determinate of plates number. Liquid-liquid extraction Simultaneous momentum, heat and mass transfer. Analogy between momentum, heat and mass transfer processes. Humidification and water cooling. Evaporation		
Assessment methods	Lecture illustrated by Power Point presentation Exercises Laboratory method written test		
Recommended readings	1. Coulson J.M., Richardson J.F., Backhurst J. R., Harker J. H., Coulson & Richardson’s Chemical Engineering, Vol. 1: Fluid Flow, Heat Transfer and Mass Transfer, Butterworth-Heinemann, Oxford, 1999 2. Coulson J.M., Richardson J.F., Backhurst J. R., Harker J. H., Coulson & Richardson’s Chemical Engineering, Vol. 2: Particle Technology and Separation Processes, Butterworth-Heinemann, Oxford, 2002 3. Richardson J.F., Peacock D.G., Coulson & Richardson’s Chemical Engineering, Vol. 3: Chemical & Biochemical Reactors & Process Control, Butterworth-Heinemann, Oxford, 2007 4. Backhurst J.R., Harker J.H., Richardson J.F.,, Coulson & Richardson’s Chemical Engineering, Vol. 4: Solutions to the Problems in Vol. 1,, Butterworth-Heinemann, Oxford, 2001 5. Backhurst J.R., Harker J.H., Coulson & Richardson’s Chemical Engineering, Vol. 5: Solutions to the Problems in Volumes 2 and 3, Butterworth-Heinemann, Oxford, 2002 6. Sinnott R.K., Coulson & Richardson’s Chemical Engineering, Vol. 6: Chemical Engineering Design, Butterworth-Heinemann, Oxford, 2003 7. Denn M.M., Chemical Engineering. An introduction,, Cambridge University Press, New York, 2012		
Knowledge	to give a general introduction to the chemical engineering		

Skills	student has ability to calculate and solve different practical problems on chemical engineering
Other social competences	student understands the needs of continuous training and development in the field of chemical engineering

Course title	CHEMICAL ENGINEERING PROCESSES IN INDUSTRY		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Ewa Ekiert	**E-mail address to the person**	Ewa.Dabrowa@zut.edu.pl
Course code (if applicable)	WTiICh-2-16	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	Knowledge on processes of chemical engineering occuring in high-volume production of chemical compounds.		
Entry requirements	Chemical engineering		
Course contents	Preparation of metal catalysts with different methods: fused, co-precipitation, pressing... High pressure ammonia synthesis on a laboratory scale Preparation of chemical fertilizers processes for removing impurities from exhaust gases Visit to the production plant Technological aspects of large volume production of chemical compounds on an example production of ammonia, nitric acid, phoshorous acid, sulfur acid, titanium dioxide, syngas, chemical fertilizers, metal catalysts. Characteristics of technological processes in the aspect of limiting emissions of pollutants into the environment of air, water, solid waste. Choice of production process - Best Available Techniques.		
Assessment methods	Lecture laboratory Passing laboratory classes based on attendance and reports. Lecture - exam.		
Recommended readings	1. Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals - Ammonia, Acids and Fertilisers, 2007, https://eippcb.jrc.ec.europa.eu/reference/BREF/lvic_aaf.pdf		
Knowledge	Student knows the basic processes of chemical engineering present in large scale inorganic chemicals industry. Student has knowledge in the field of kinetics and catalysis of chemical processes and thermodynamics Student has knowledge of development trends in the chemical industry		
Skills	Student is able to plan and perform chemical experiments, interpret obtained results and draw correct conclusions.		
Other social competences	Student can independently apply the ideas of sustainable development in industrial chemical processes		

Course title	CHEMICAL ENGINEERING PROCESS SIMULATION USING ASPEN PLUS		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Halina Murasiewicz	**E-mail address to the person**	Halina.Murasiewicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-15	**ECTS points**	5
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The student will be able to: 1. Develop the process models based on conservation principles. 2. Use Aspen Plus to model chemical engineering processes.		
Entry requirements	Fundamentals of chemical engineering		
Course contents	Selected process simulation in Aspen Plus. Introduction to chemical engineering process simulation. Introduction to the Aspen Plus interface. Simulation file creation. Basic process options and simulation tools in Aspen Plus. Selecting physical property models. The data regression system. Unit operation models. Reaction and reactors. Separation columns. Processes with recycle. Sensitivity analysis. Optimization.		
Assessment methods	Lecture illustrated by Power Point presentation and computer simulation in ASPEN Laboratory Periodic assessment of student achievement Lecture: exam at the end of the semester Laboratory: assessment of reports		
Recommended readings	1. Hangos K.M., Cameron L.T., Process modelling and model analysis, Academic Press, 2001 2. Dhurjati P., Shiflett M., Modeling and simulation in chemical engineering using Aspen and Matlab, CRC Press, 2014 3. Rice R.G., Do D.D., Applied mathematics and modeling for chemical engineers, Wiley, New York, 2012 4. Finlayson B.A., Introduction to chemical engineering computing, Wiley, New York, 2005 5. Schefflan R., Teach Yourself the Basics of Aspen Plus, Wiley, New York, 2011 6. Luyben W.L., Chemical Reactor Design and Control, Wiley, New York, 2007		
Knowledge	The student will be able to develop the process models based on conservation principles.		
Skills	The student will be able to use Aspen Plus to model chemical engineering processes.		
Other social competences	The student will be able to model chemical engineering processes.		

Course title	CHEMICAL PROCESS EQUIPMENT		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Halina Murasiewicz	**E-mail address to the person**	Halina.Murasiewicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-17	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The student will be able to: 1.Identify the various types of equipment used in the chemical-processing industry. 2.Explain the basic elements of chemical process equipment. 3.Describe the scientific principles associated with chemical process equipment. 4.Describe the operation and maintenance of chemical process equipment. 5.Troubleshoot typical problems associated with the operation of chemical process equipment. 6.Describe the basic instruments used in the process industry. 7.Identify and draw standard instrument symbols. 8.Describe temperature, pressure, flow, and level-measurement techniques. 9.Identify the elements of a control loop. 10.Describe the various concepts associated with utility systems		
Entry requirements	Fundamentals of chemical engineering		
Course contents	Flowsheets. Calculation of flow of fluids and fluid transport equipment. Calculation of heat transfer and heat exchangers. Calculation of dryers and cooling towers. Calculation of separation equipment (distillation, absorption, adsorption and ion exchange). Process equipment cost estimation. Basic terms. Introduction to process equipment. Flowsheets. Drivers for moving equipment. Flow of fluids. Fluid transport equipment. Pumps, compressors, turbines and motors. Valves: applications and theory of operation. Tanks, piping, and vessels. Heat transfer and heat exchangers. Dryers and cooling towers. Mixing and agitation. Boilers. Furnaces. Instruments. Process control diagrams. Utility systems. Reactor Systems. Distillation and absorption systems. Adsorption and ion exchange. Crystallization from solutions and melts. Extraction. Other separation systems. Plastics Systems. Costs of individual equipment.		
Assessment methods	Lecture illustrated by Power Point presentation and computer simulation Classis illustrated by computer and manual calculations Periodic assessment of student achievement Lecture: exam at the end of the semester Classis: written test		
Recommended readings	1. Thomas Ch. E., Process technology equipment and systems, Cengage Learning, Stamford, 2015 2. Walas S. M., Chemical Process Equipment, Butterworth-Heinemann, Newton, 1990 3. Cheremisinoff N. P., Handbook of Chemical Processing Equipment, Butterworth-Heinemann, Boston, 2000 4. Elizabeth T. Lieberman E. T., Norman P., Lieberman N., A Working Guide to Process Equipment, McGraw-Hill, New York, 2008		
Knowledge	The student will be able to Identify the various types of equipment used in the chemical-processing industry.		
Skills	The student will be able to describe the operation and maintenance of chemical process equipment.		
Other social competences	The student will be able to describe the scientific principles associated with chemical process equipment.		

Course title	CHEMICAL PROCESSES IN INORGANIC INDUSTRY AND ENVIRONMENTAL ENGINEERING		
Level of course	second cycle		
Teaching method	lecture		
Person responsible for the course	Sylwia Mozia	**E-mail address to the person**	Sylwia.Mozia@zut.edu.pl
Course code (if applicable)	WTiICh-2-18	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Student will get theoretical knowledge on chemical processes in inorganic industry and environmental engineering, including technologies of flue gas desulfurization and NOx removal, purification of air, production of building and construction materials, as well as electrochemical methods of synthesis of inorganic compounds and treatment of metal surfaces.		
Entry requirements	Fundamentals of chemistry and chemical technology		
Course contents	Part I: Technologies of flue gas desulfurization and NOx removal, purification of air: general information concerning pollution with SOx and NOx, EU regulations, sources of sulfur and formation of SOx, wet and dry methods applied for desulfurization of flue gases, modern regenerative methods, formation of NOx during combustion of fuels, removal of NOx from flue gases including catalytic methods, preparation of pure air. Part II: Building materials. Lime, gypsum, cement, concrete, prefabricated products. Ceramics: ceramic building materials, electroceramics, metal ceramics, ceramic whiteware. Glass and glassware. Different sorts of glass, glass wool, ceramic and glass fibres, frits. Part III: Industrial electrochemistry: electrolysis of aqueous solutions; electrolysers; factors influencing electrolysis; electrolysis of aqueous solutions of NaCl; electrolysis of spent HCl; electrochemical treatment of metal surfaces – electroplating; hydroelectrometallurgy; electrochemical synthesis of inorganic compounds		
Assessment methods	lecture class test/grade		
Recommended readings	1. Ron Zevenhoven, Pia Kilpinen, Control of pollutants in flue gases and fuel gases, ISBN 951-22-5527-8 (available online) 2. Boynton R.S., Chemistry and technology of lime and limestone, John Wiley, New York 1980 3. ed. R.D. Hooton, Cement, Concrete, and Aggregates, ASTM International, West Consh., PA 2003 4. Hocking M.B., Modern Chemical Technology and Emission Control, Springer-Verlag, Berlin 1985 5. Volf M.B., Chemical approach to glass, Elsevier, Amsterdam 1984 6. Pletcher D., Walsh F. C., Industrial Electrochemistry, Springer-Verlag GmbH, 2007 7. Wendt H., Kreysa G., Electrochemical Engineering: Science and Technology in Chemical and Other Industries, Springer Science & Business Media, 1999		
Knowledge	At the completion of this course, students will be able to: - Explain fundamentals of chemical processes applied in industry, including processes of flue gas desulfurization, NOx removal, and purification of air, processes and methods applied in building and construction industry and well as electrochemical processes utilized for production of organic and inorganic compounds, in electroplating and hydroelectrometallurgy. - Describe the properties of materials and the engineering aspects for various chemical processes applied in inorganic industry.		
Skills	At the completion of this course, students will be able to: - Analyze and propose methods of manufacturing of numerous products using chemical processes. - Analyze and propose methods of purification of flue gases emitted by chemical industry.		
Other social competences	Student understands the needs of continuous training and development in the field of chemical processes in inorganic industry		

Course title	CHEMICAL REACTION ENGINEERING		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Halina Murasiewicz	**E-mail address to the person**	Halina.Murasiewicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-19	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The student will be able to: 1.Describe and define the rate of reaction. 2.Derive the mass balance equation. 3.Apply the mass balance equation to the most common types of industrial reactors. 4.Write the rate law in terms of concentrations, and temperature. 5.Use nonlinear regression to determine the rate law parameters. 6.Apply the differential and integral methods for analysis of reactor data. 7.Define a catalyst and describe its properties. 8.Describe the steps in a catalytic reaction. 9.Suggest a mechanism and apply the concept of a rate-limiting step to derive a rate law.		
Entry requirements	Fundamentals of chemical engineering		
Course contents	Derivation of general mass balance equations. Reactor sizing. Analysis of stoichiometry. Analysis of rate data. Analysis of catalytic reactors . Analysis of three-phase reactors. Analysis of isothermal and nonisothermal reactors. Analysis of biochemical reactors. Chemical reactor Design using ASPEN Plus. Introduction. Fundamental concepts. The General Mass Balance Equation. Reactor sizing. Stoichiometry. Conversion. The Reaction Order. The Rate Law. Collection and analysis of rate data. Multiple reactions. Reaction mechanisms. Catalytic reactors. Three-phase reactors. Isothermal and nonisothermal reactor design. Biochemical reactors.		
Assessment methods	Lecture illustrated by Power Point presentation and computer simulation Classis illustrated by computer and manual calculations Periodic assessment of student achievement Lecture: exam at the end of the semester Classis: written test		
Recommended readings	1. Fogler H.S., Elements of chemical reaction engineering, Prentice-Hall, New Jersey, 2009 2. Levenspiel O., Chemical reaction engineering, Wiley, New York, 1999 3. Luyben W.L., Chemical reactor design and control, Wiley, New York, 2007		
Knowledge	The student will be able to: 1.Describe and define the rate of reaction. 2.Derive the mass balance equation. 3.Write the rate law in terms of concentrations, and temperature. 4.Define a catalyst and describe its properties. 5.Describe the steps in a catalytic reaction.		
Skills	The student will be able to: 1.Apply the mass balance equation to the most common types of industrial reactors. 2.Use nonlinear regression to determine the rate law parameters. 3.Apply the differential and integral methods for analysis of reactor data.		
Other social competences	The student will be able to suggest a mechanism and apply the concept of a rate-limiting step to derive a rate law.		

Course title	CHROMATOGRAPHIC METHODS		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Małgorzata Dzięcioł	**E-mail address to the person**	Malgorzata.Dzieciol@zut.edu.pl
Course code (if applicable)	WTiICh-2-20	**ECTS points**	5
Semester	winter/summer	**Language of instruction**	english
Hours per week	6	**Hours per semester**	90
Objectives of the course	Knowledge of theoretical and practical aspects of chromatographic methods		
Entry requirements	Basic knowledge of organic chemistry		
Course contents	Maintenance and method development in gas chromatography. Evaluation of separation efficiency. Qualitative and quantitative analysis in gas chromatography. Application of GC-MS method in identification of compounds. Qualitative and quantitative analysis in liquid chromatography. General theory of chromatography. Classification of chromatographic methods. Retention parameters. Resolution. Separation efficiency of column. Identification and quantification methods in chromatography. Gas chromatography (GC) – principles, instrumentation, carrier gas, columns and stationary phases, sampling, detectors, applications. High performance liquid chromatography (HPLC) – instrumentation, eluents, stationary phases, normal and reversed-phase chromatography, isocratic and gradient elution, detectors, applications. Thin layer chromatography (TLC) – principles, adsorbents and plates, chambers, development techniques, densitometry. Written test (grade)		
Assessment methods	Lecture with presentation and discussion Laboratory Consultations Evaluation of working in the laboratory Evaluation of written reports Grade		
Recommended readings	1. Braithwaite A., Smith F.J., Chromatographic Methods, Springer, 1996 2. McNair H.M., Miller J.M., Basic Gas Chromatography, Wiley, 2009, II edition 3. Snyder L.R., Kirkland J.L., Dolan J.W., Introduction to Modern Liquid Chromatography, Wiley, 2010		
Knowledge	Student will be able to classify chromatographic methods and describe different chromatographic separation processes. Student will be able to describe instrumentation used in chromatography.		
Skills	Student will be able to apply chromatographic methods in order to perform qualitative and quantitative analysis of organic compounds.		
Other social competences	Student is aware of the responsibility for the results of analyses.		

Course title	COLLOID AND INTERFACE CHEMISTRY		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Ewa Janus	**E-mail address to the person**	Ewa.Janus@zut.edu.pl
Course code (if applicable)	WTiICh-2-21	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Student has knowledge in the field of fundamental principles in colloids and interface chemistry Student has knowledge in versatile phase behaviour of surfactants and polymers and diversity in colloidal structure formed by surfactants Student is able to characterize the colloids formed by surfactants and surfactants adsorption on the interfaces i colloidal systems Understanding of fundamental principles in colloids and interface chemistry Understanding of versatile phase behaviour of surfactants and polymers and diversity in colloidal structure formed by surfactants Characterization the colloids formed by surfactants and surfactants adsorption on the interfaces in colloidal systems		
Entry requirements	Principles in Chemistry		
Course contents	Determination of cloud points of non-ionic surfactants. Effect of chemical structure on the cloud point. Determination of the surface tension of surfactant solutions-effect of surfactants structure and additives. Critical micelle concentration of surfactants - determination by surface tension and conductivity measurements Determination of Kraft point and solubility of surfactants Determination of required HLB for oil components and oil phase Formation of emulsions and determination of their stability Colloids definition and key terms used in the colloids chemistry Association colloids formed by surfactants. Characteristic features of surfactants, classification and chemical structures of surfactants; criteria of application Surfactant solubility; self-assembled surfactants aggregates - micelles and critical micelle concentration, factors affecting the CMC, structure of micelle and molecular packing; liquid crystalline mesophases; Adsorption of surfactants at interfaces - surface tension, surface excess; interfacial tension, contact angle, wetting of surfaces and methods of measurements Polymers at interfaces; effect of polymers on colloid stability Formation and stabilization of colloids: emulsions, microemulsions, foams, solid/liquid dispersions; forms of colloids instability Colloids in products and processes		
Assessment methods	Laboratory Lectures Discussion lab report continuous assessment Written exam		
Recommended readings	1. Terence Cosgrove, Colloid Science Principles, methods and applications, WILEY, 2010, 2nd ed. 2. Milton J. Rosen, Joy T. Kunjappu, Surfactants and Interfacial Phenomena, WILEY, 2012, 4th Edition 3. R. J. Farn (Ed.), Chemistry and Technology of Surfactants, Blackwell Publishing, 2006 4. European standards, 2011 5. M. R. Potter, Handbook of surfactants, Springer Science + Business Media, 1993, Chapter 4 6. Krister Holmberg, Bo Jonsson, Bengt Kronberg and Bjorn Lindman, Surfactants and Polymers in Aqueous Solution, John Wiley & Sons, Ltd., 2002, 2nd ed.		
Knowledge	student has knowledge in fundamental principles in colloids and interface chemistry Student has knowledge in versatile phase behaviuor of surfactants and polymers and diversity in colloidal structures formed by surfactants		
Skills	Student is able to characterize the colloids and phenomena of interfacial adsorption in systems containing surfactants		

Course title	CORROSION AND ANTICORROSION PROTECTION OF MATERIALS		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Krzysztof Kowalczyk	**E-mail address to the person**	Krzysztof.Kowalczyk@zut.edu.pl
Course code (if applicable)	WTiICh-2-22	**ECTS points**	3
Semester	summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	To gain the knowledge, skills and competences in the field of: - corrosion processes, - prediction of corrosion resistance of materials in relation to their physicochemical features, - anticorrosion protection method.		
Entry requirements	Chemia nieorganiczna Materiałoznawstwo		
Course contents	Preparation of barrier-type and corrosion inhibition-typ protective coatings Corrosion processes analysis by electrochemical polarisation methods Corrosion processes investigation by the electrochemical noise method. Galvanic corrosion of metals. Acceleration tests of corrosion protective coatings. Corrosion and its types, mechanisms of metalic and organic materials corrosion Electrochemical corrosion, electrochemical potential, standard electrode potential, theoretical nad practical galvanic series, cell types Polarisation and its types, polarisation and depolarisation agents Chemical nad microbiological corrosion Corrosion control methods Analysis of corrosion processes		
Assessment methods	wykład informacyjny ćwiczenia laboratoryjne zaliczenie pisemne sprawozdanie		
Recommended readings	1. Wranglen G., An Introduction to Corrosion and Protection of Metals, Springer Netherlands, 1985 2. Uhling H.H., Corrosion and Corrosion Control: An Introduction to Corrosion Science and Engineering, John Wiley & Sons, Inc., 2008		
Knowledge	To gain a detailed theoretical knowledge of the corrosion of materials and anticorrosion protection methods		
Skills	To gain a practical knowledge of the corrosion of materials and anticorrosion protection methods		
Other social competences	Student understands the technical importance of material corrosion and anticorrosion protection method applications		

Course title	COSMETIC CHEMISTRY		
Level of course	second cycle		
Teaching method	laboratory course		
Person responsible for the course	Beata Kołodziej	**E-mail address to the person**	Beata.Kolodziej@zut.edu.pl
Course code (if applicable)	WTiICh-2-23	**ECTS points**	2
Semester	summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	Familiarize students with principles of choosing the conditions (e.g. emulsifier) for obtaining stable cosmetic emulsions Familiarize students with principles of volumetric analysis. Correct interpretation of the results of preparation of cosmetics and analytical determination of some cosmetic ingredients.		
Entry requirements	The basic knowledge of fundamental, inorganic, and organic chemistry		
Course contents	Preparation of emulsions (studying the impact of the type of emulsifier, temperature, mixing time etc. on emulsion stability). Emulsion type tests Quantification of cosmetic ingredients (analytical chemistry - volumetric analysis) Preparation of toothpastes, shaving creams, shampoos, facial cleaning preparations, and soaps		
Assessment methods	laboratory discussion Continuous assessment: lab activity and reports		
Recommended readings	1. A.O. Barel, M. Paye, H.I. Maibach, Hanbook of Cosmetic Science and Technology, Informa Healthcare USA, Inc., New York, 2009 2. Heather A.E. Benson, Michael S. Roberts, Vania Rodrigues Leite-Silva, Kenneth Walters, Cosmetic Formulation. Principles and Practice, 2009		
Knowledge	Knowledge about cosmetics preparation and volumetric analysis of some cosametic ingredients		
Skills	As a result of the course the student should be able to: - select process conditions to obtain a stable emulsion, - analyze the results obtained and properly interpret them.		
Other social competences	Correct interpretaion of the results.		

Course title	COSMETIC FORMULATION		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Paula Ossowicz	**E-mail address to the person**	Paula.Ossowicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-24	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Student has knowledge of typical group of cosmetic raw materials - their chemical structure, the most important properties and functions in cosmetics. Student can recognize relationship between structure and properties and applications of raw materials. Student can name and describe steps in the production of cosmetics. Student can prepare different cosmetic formulations (solutions, emulsions, gels, suspensions), using the knowledge of raw materials and their impact on the physicochemical form of the cosmetic and its application. Student can assess and control the quality of the cosmetic formulation.		
Entry requirements	organic chemistry inorganic chemistry		
Course contents	Shampoos and liquids soaps formulation quantity analysis of the anionic surfactant. Formulation of lotions – micellar lotion, tonic, hair lotion. Formulation of emulsions – lotions and creams. Choice of the emulsifier. Gels in cosmetics and personal care products. Toilet and metallic soaps – Obtaining and characteristic. Fats and oils in cosmetics - analysis in skin care products. Definition of a cosmetic, nomenclature of cosmetic ingredients and their functions, application limits and requirements, information on the label, graphic symbols, the safety of raw materials and the cosmetic product Basic cosmetic raw materials and their characteristics (solvents, mineral and silicone oils, emollients, lipid raw materials and waxes, surfactants) Enzymes in cosmetics, low molecular weight peptides, protein hydrolysates, biogenic proteins. Lifting and anti-aging agents. UV filters, antiperspirants. Oral and dental care products. Varnishes and nail polish removers.		
Assessment methods	laboratory lectures project work continuous assesment final written test - lectures		
Recommended readings	1. H. Mollet, A. Grubenmann, Formulation Technology. Emulsions, suspensions, solid forms, Wiley-VCH, Weinheim, 2001 2. I. D. Morrison, S. Ross, Colloidal dispersions, Suspensions, Emulsions and Foams, Wiley-Interscience, New York, 2002 3. A. O. Barel, M. Paye, H. I. Maibach (Eds.), Handbook of Cosmetic Science and Technology, Informa Healthcare, 2009, third		
Knowledge	Student will have knowledge of production of different cosmetic formulation, effect of cosmetic ingredients on application and quality of formulation		
Skills	Student prepares various cosmetic formulations (solutions, emulsions, gels, suspensions) using the knowledge about raw materials and their impact on the physicochemical form of the cosmetic; the student is able to assess and control the quality of the cosmetic formulation; the student uses the rules and requirements set out in the cosmetics law		
Other social competences	Student is aware of the importance of legal and health aspects related to the formulation of cosmetic products and the need to expand knowledge in this field		

Course title	DRYING TECHNIQUES		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Konrad Witkiewicz	**E-mail address to the person**	Konrad.Witkiewicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-25	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The student will be able to: 1. Demonstrate basic knowledge of thermodynamics of moist gas and solid. 2. Explain the basic elements of drying kinetics. 3. Identify the various types of drying methods. 4. Demonstrate basic knowledge of applications and design of dryers. Student will be able to solve typical problems associated with dryers design and modeling.		
Entry requirements	Basic knowledge of mathematics.		
Course contents	Solving problems presented during lectures. Moisture in gases and solids: thermodynamic of moist gas, thermodynamic of moist solids. Heat and mass transfer in drying processes. Drying kinetics. Experimental methods in drying. General principles of dryer design. Mathematical modeling of drying processes. Drying in energy fields. Performance of modern industrial dryers. Miscellaneous drying problems: selection of dryer, energy aspects. Procedures for choosing of a dryer. Selection schemes. Batch dryers (e.g. Vacuum dryers, Fluid-bed batch dryers, Tray dryers, Agitated pan dryers etc.). Continuous dryers – selection tree (e.g. Conduction dryer with inert stripping gas, e.g. plate dryer, Milling/flash drying, Band (Belt) dryer, Flash dryer, possibly with product recirculation, Convection/conduction dryer with rotating shell or agitation, e.g. disc or rotary dryer, Fluid-bed dryer, circular stirred tank rectangular, spray dryer, Miscellaneous continuous dryers, etc.). Processing liquids, slurries, and pastes (Spray dryers, Film drum dryers, Continuous Fluid-bed dryers/Granulators, Cylindrical scraped-surface evaporator/Crystallizer/Dryer, Agitated pan or vacuum dryers). Special drying techniques (Infrared drying, Dielectric drying, Freeze-drying, Steam drying). Qualitative comparison of Convective, Conduction, and Dielectric dryer types. Testing on Small-scale dryers. Example of dryer selection procedure.		
Assessment methods	Lecture Classes Lecture: written exam Classes: written test		
Recommended readings	1. C. Strumiłło, T. Kudra, Drying: Principles, Applications and Design, Gordon and Breach Sci. Publ., New York, 1986 2. C.M. Van ’t Land, Drying in the Process Industry, John Wiley & Sons, Inc., New York, 2012		
Knowledge	Student demonstrates basic knowledge of drying techniques.		
Skills	Student can solve problems associated with dryers design and modeling of drying process.		
Other social competences	Student understands the need for continuous training and development in the field of drying techniques.		

Course title	ELECTRICAL ENGINEERING FOR CHEMISTS		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Dariusz Moszyński	**E-mail address to the person**	Dariusz.Moszynski@zut.edu.pl
Course code (if applicable)	WTiICh-2-26	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Student knows the principal laws of electrical engineering Student knows basic electrical appliances and is able to apply them properly Student is able to build simple electric circuits and to measure electrical properties		
Entry requirements	Math Physics		
Course contents	Electrical circuity - basics Electrical measurement DC network analysis Kirchhoff’s law Polyphase AC circuits Basic concepts of electricity Electrical safety Series and parallel circuits. Kirchhoff’s law. DC network analysis. Batteries and power systems Magnetism and electromagnetism. Basic AC Theory Transformers, Generators, Motors. Polyphase AC circuits		
Assessment methods	Lecture Laboratory Exam		
Recommended readings	1. Sarma, Mulukutla S., Introduction to Electrical Engineering, Oxford University Press, 2001		
Knowledge	Student knows the principal laws of electrical engineering		
Skills	Student is able to build simple electric circuits and to measure electrical properties		
Other social competences	Student recognizes basic electrical circuits		

Course title	ENGINEERING GRAPHICS AND DESIGN		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Grzegorz Story	**E-mail address to the person**	Grzegorz.Story@zut.edu.pl
Course code (if applicable)	WTiICh-2-27	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Mastering the ability to read and perform technical drawings, machine diagrams, installation diagrams, devices, technical systems in accordance with the principles of technical drawing. Mastering the computer technique of creating and modifying drawings based on AutoCAD.		
Entry requirements	None		
Course contents	Introduction to AutoCAD. Prepare technical drawings with AutoCAD requiring students to set units, limits, layers, and utilize the tools of AutoCAD's Draw, Modify, and Dimension toolbars. Create AutoCAD dimension styles. Draw section views of machine parts. Prepare auxiliary views of machine parts. Create 3D models of machine parts. Introduction to Drawing. Lines and Conventional Breaks. Lettering Techniques and Dimensioning with Tolerances. Geometrical Construction. Scales.Theory of Projection. Projection of Solid. Orthographic Projection. Sectional Views. Isometric Projection. Development of Surfaces. Screw Threads and Fasteners. Rivets and Riveted Joints. Welded Joint. Floor Plan. Written test		
Assessment methods	Activating methods: lecture illustrated by multimedia presentation and didactic discussion Practical methods: computer exercises written test Execution of technical drawings of the selected object.		
Recommended readings	1. Mohd Parvez; Osama Khan, Engineering Graphics and Design, Bhavya Books, New Delhi, 2019, 1		
Knowledge	Students will acquire detailed theoretical knowledge on many aspects within the framework of the graphics engineering		
Skills	Students will acquire practical knowledge on many aspects within the framework of the graphics engineering		
Other social competences	Students understand the needs of continuous training and development in the field of graphics engineering		

Course title	ENVIRONMENTAL POLLUTION CONTROL		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Halina Murasiewicz	**E-mail address to the person**	Halina.Murasiewicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-28	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The student will be able to: 1. Identify the various types of air, water, and soil pollutants. 2. Explain the effects of pollutants on human beings and environment. 3. Describe the sources of air, water, and soil pollutants. 4. Demonstrate basic knowledge of control technologies preventing air, water, and soil pollution.		
Entry requirements	Fundamentals of chemical engineering		
Course contents	Analysis of methods used for air pollution control: absorption, adsorption, biofiltration, catalytic destruction, particles capture. Analysis of methods used for waste water treatment: aerobic and anerobic digesters, activated sludge process. Analysis of methods used for monitoring and control of soil pollution. Introduction. Basic concepts. Air pollution. Smog in troposphere. Ozone depletion in stratosphere. Acid Rain. Aerosols: deposition and nucleation. Control of air pollution: absorption; adsorption, biofiltration, catalytic destruction. Particles capture. Water pollution: organic, inorganic, biological. Waste water treatment: aerobic and anerobic digesters, activated sludge process. Soil pollution: types of soil pollution, sources of soil pollution, effects of soil pollution. Monitoring and control of soil pollution.		
Assessment methods	Lecture illustrated by Power Point presentation and computer simulation Classis illustrated by computer and manual calculations Periodic assessment of student achievement Lecture: exam at the end of the semester Classis: written test		
Recommended readings	1. Peirce J.J., Vesilind P.A., Weiner R.F., Environmental Pollution and Control, Elsevier, Amsterdam, 1997 2. Flagan R.C.,, Fundamentals of air pollution engineering, Prentice-Hall, New Jersey, 1988 3. Hill M.K., Understanding Environmental Pollution. A Primer, Cambridge University Press, Cambridge, 2004 4. Mirsal I.A., Soil Pollution: Origin, Monitoring and Remediation, Springer, Berlin, 2004		
Knowledge	The student will be able to identify the various types of air, water, and soil pollutants.		
Skills	The student will be able to explain the effects of pollutants on human beings and environment.		
Other social competences	The student will be able to demonstrate basic knowledge of control technologies preventing air, water, and soil pollution.		

Course title	FLUID MECHANICS		
Level of course	second cycle		
Teaching method	lecturing course / laboratory course / lecture		
Person responsible for the course	Anna Story	**E-mail address to the person**	Anna.Story@zut.edu.pl
Course code (if applicable)	WTiICh-2-29	**ECTS points**	4
Semester	summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	Understanding basic laws, principles and phenomena in the area of fluid mechanics Theoretical and practical preparation enabling students to apply the acquired knowledge and skills in professional and specialist courses		
Entry requirements	Chemical engineering fundamentals Applied Mathematics		
Course contents	Solving exercises related to the content of the lecture. Written test Laboratories include experiments related to the determination of liquids properties and their flow in process equipment, for example, determination of the viscosity and density of liquids, determination of the Reynolds number, characterization of the mixing time in a mechanical mixer, liquid outflow from the tank, analysis of liquid velocity using LDA method, visualization of fluid flow. Introduction. The concept of the continuum and kinematics (properties of fluids, continuum hypothesis, kinematics) Fundamental laws of continuum mechanics (conservation of mass, equation of continuity, balances of momentum, angular momentum, energy, entropy, thermodynamic equations of state) Constitutive relations for fluids Equations of motion for particular fluids (Newtonian fluids, inviscid fluids, initial and boundary conditions, simplification of the equations of motion) Hydrostatics Laminar unidirectional flows (steady unidirectional flows, unsteady unidirectional flows, unidirectional flows of non-Newtonian fluids, Bingham material) Fundamentals of turbulent flow (stability and the onset of turbulence, Reynolds' equations, turbulent shear flow near a wall, turbulent flow in smooth pipes and channels, turbulent flow in rough pipes) Hydrodynamic lubrication (Reynolds' equation of lubrication theory, statically and dynamically loaded bearing, thin-film flow on a semi-infinite wall, flow through particle filters, flow through a porous medium, Hele-Shaw flows) Stream filament theory (incompressible flow, steady compressible flow, unsteady compressible flow) Potential flows (one-dimensional propagation of sound, steady compressible potential flow, incompressible potential flow, plane potential flow) Boundary layer theory Written test		
Assessment methods	Activating methods: lecture illustrated by multimedia presentation and didactic discussion Practical methods: calculation of exercises Practical methods: laboratory exercises Lectures - written final test Classes - written final test Laboratory - individual report after each laboratory		
Recommended readings	1. Joseph H. Spurk, Nuri Aksel, Fluid Mechanics, Springer-Verlag Berlin Heidelberg, Leipzig, Germany, 2008, 2nd Edition, ISBN 978-3-540-73536-6 2. Frank M. White, Fluid Mechanics, McGraw-Hill, New York, 2011, 7th Edition, ISBN 978-0-07-352934-9		
Knowledge	Students will acquire detailed theoretical knowledge on many aspects within the framework of the fluid mechanics		
Skills	Students will acquire practical knowledge on many aspects within the framework of the fluid mechanics		
Other social competences	Students have the ability to solving and analyzing processes in the field of fluid mechanics. Students understand the needs of continuous training and development in the field of fluid mechanics		

Course title	FUNDAMENTAL OF PHYSICAL CHEMISTRY		
Level of course	second cycle		
Teaching method	lecturing course / laboratory course / lecture		
Person responsible for the course	Krzysztof Lubkowski	**E-mail address to the person**	Krzysztof.Lubkowski@zut.edu.pl
Course code (if applicable)	WTiICh-2-30	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	5	**Hours per semester**	75
Objectives of the course	Understanding of real fenomena in physical chemistry. Ability of prediction of physicochemical properties of materials.		
Entry requirements	Basis of inorganic and organic chemistry		
Course contents	Physicochemical calculations related to thermodynamics, thermochemistry and solutions and phase equilibria Laboratory units related to physicochemical properties of materials, thermodynamics, thermochemmistry, solutions and phase equilibria Characteristics of individual states of aggregation, Clapeyron and van der Waals equations, kinetic theory of gases Phenomenological thermodynamics. Gibbs-Helmholtz equation, reversible and irreversible processes, spontaneity of processes, termochemistry, heat of reaction, Hess law, heat capacity, Kirchoff's law, Phase equilibria, Gibbs phase rules, lever rule, Claussius-Clapeyron equation, Solutions, classification of solutions, Raoult and Henry equation, thermodynamics of mixing, Activity, mixing functions, Gibbs-Duhem equation. Chemical statics		
Assessment methods	Lectures with discussion Classes Laboratory units written exam and/or oral discussion assessment of laboratory report		
Recommended readings	1. Sun, Siao F., Physical chemistry of macromolecules : basic principles and issues, Hoboken : John Wiley & Sons, 2004 2. Uziel Zbigniew, Żak Jerzy, asic calculations in physical chemistry. Pt. 1, . The properties of gases, thermodynamics, chemical equilibrium, Gliwice : Silesian University of Technology, 2004 3. Raff, Lionel M, Principles of physical chemistry, Upper Saddle River : Prentice Hall, 2001		
Knowledge	student knows the phenomena of physical chemistry		
Skills	student is able to plan and carry out the experiment with the interpretation of obtained results		
Other social competences	student is able to choose the appropriate method in order to solve the problem related to physical chemistry		

Course title	GAS CLEANING METHODS AND TECHNOLOGIES		
Level of course	second cycle		
Teaching method	seminars / lecture		
Person responsible for the course	Jacek Przepiórski	**E-mail address to the person**	Jacek.Przepiorski@zut.edu.pl
Course code (if applicable)	WTiICh-2-31	**ECTS points**	2
Semester	winter/summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	to posses knowldege on the practicall methods and technologies used to clean gases from various sources		
Entry requirements	Basics of chemistry		
Course contents	Seminars on topics from the lecture: SOx and NOX elimination from flue gases, methods of other gases arresting from industrial fluxes Processes releasing harmful gases, sources of sulfur and nitrogen in fuels, generation of SO2 upon combustion of fuels. Industrial methods for SO2 removal from flue gases (DeSOx). Formation of nitrogen oxides upon combustion of fuels, technologies for NOx removal (DeNOx) from flue gases. Other methods and technologies for purification of air and other gaseous streams including H2S arresting.		
Assessment methods	Lecture Oral exam, continuous assessment		
Recommended readings	1. Zevenhoven, R., Kilpinen, P., CONTROL OF POLLUTANTS IN FLUE GASES AND FUEL GASES, 2011, http://users.abo.fi/rzevenho/gasbook.html		
Knowledge	You will know and understand some chemical processes, particalurarly related to releasing of hazardous gases. You will know porocesses used to clean the gases before releasing to the atmosphere.		
Skills	W wyniku przeprowadzonych zajęć student powinien umieć dobrać metodę oczyszczania gazu do jego składu		
Other social competences	W wyniku przeprowadzonych zajęć student nabędzie następujące postawy: dbałość o środowisko, świadomość zagrożeń, zdolność do zdecydowania o potrzebie oczyszczania gazów.		

Course title	HEAT TRANSFER		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Maciej Konopacki	**E-mail address to the person**	mkonopacki@zut.edu.pl
Course code (if applicable)	WTiICh-2-32	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	The student will be able to: 1.Identify the different modes of heat transfer. 2.Formulate basic equation for heat transfer problems. 3.Solve differential and algebraic equations associated with heat transfer using analytical and numerical methods. 4.Apply heat transfer principles to design heat exchanger. 5.Apply Aspen Plus to design of heat exchanger.		
Entry requirements	Fundamentals of chemical engineering Physics Mathematics		
Course contents	Analysis of heat conduction. Analysis of convective heat transfer: laminar and turbulent. Analysis of simultaneous heat and mass transfer. Analysis of boiling and condensation. Heat exchanger calculations. Introduction. Heat conduction. Convective heat transfer: laminar and turbulent. Simultaneous heat and mass transfer. Boiling. Condensation. Radiation. Heat exchanger: type of equipment. Heat exchanger calculations. Design of heat exchanger.		
Assessment methods	Lecture illustrated by Power Point presentation and computer simulation Classis illustrated by computer and manual calculations Periodic assessment of student achievement Lecture: exam at the end of the semester Classis: written test		
Recommended readings	1. Incropera F.P., Lavine A.S., DeWitt D.P., Fundamentals of Heat and Mass Transfer, Wiley, New York, 2011 2. Rathore M.M., Kapuno R.R., Engineering Heat Transfer, Jones & Bartlett Learning, Sudbury, 2011		
Knowledge	The student will be able to: 1.Identify the different modes of heat transfer. 2.Formulate basic equation for heat transfer problems.		
Skills	The student will be able to: 1.Solve differential and algebraic equations associated with heat transfer using analytical and numerical methods. 2.Apply Aspen Plus to design of heat exchanger.		
Other social competences	The student will be able to apply heat transfer principles to design heat exchanger.		

Course title	HETEROGENEOUS CATALYSIS IN INDUSTRY		
Level of course	second cycle		
Teaching method	lecturing course / laboratory course / lecture		
Person responsible for the course	Dariusz Moszyński	**E-mail address to the person**	Dariusz.Moszynski@zut.edu.pl
Course code (if applicable)	WTiICh-2-33	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	Student knows the principles of heterogeneous catalysis Student knows the fundamental structure and composition of catalysts as well as the processes leading to the preparation of industrial catalysts Student knows the most important industrial processes where heterogeneous catalysis play the major role Student is able to prepare samples of catalysts and evaluate their properties		
Entry requirements	Inorganic chemistry Organic chemistry		
Course contents	Chemical kinetics in catalysis - basic equations Mass and energy in catalytic processes Modeling of industrial catalytic processes Ammonia decomposition over iron catalyst High pressure ammonia synthesis Catalytic nanotubes formation Catalyst and catalysis in heterogeneous systems Catalyst preparation, deactivation, regeneration The experimental methods for catalysts' examination Industrial catalytic processes in inorganic, organic and polymer industries		
Assessment methods	Lecture Cases Exam		
Recommended readings	1. Ross, Julian, Heterogeneous CatalysisCatalysis - Fundamentals and Applications, Elsevier, 2012		
Knowledge	Student knows the principles of heterogeneous catalysis		
Skills	Student is able to prepare samples of catalysts and evaluate their properties		
Other social competences	Student is competent in heterogeneous catalysis		

Course title	INDUSTRIAL AUTOMATION AND PROCESS CONTROL FOR CHEMISTS		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Dariusz Moszyński	**E-mail address to the person**	Dariusz.Moszynski@zut.edu.pl
Course code (if applicable)	WTiICh-2-34	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Let to know the principles of automation and process control Let to know standard automation equipement Learn how to choose and apply the proper automation solution		
Entry requirements	Math Physics Electrical engineering		
Course contents	Electronic data acquisition and control Temperature control in chemical process Pressure and flow control for gases and liquids The principles of automation and process controll Automation equipement Design and application of automation in chemical engineering		
Assessment methods	Lecture Case analysis Laboratory Exam Activity assesement		
Recommended readings	1. Chaudhuri, Uttam Ray; Chaudhuri, Utpal Ray, Fundamentals of Automatic Process Control, Taylor & Francis, 2013		
Knowledge	Student knows the principles of regulation and automation		
Skills	Student is able to chose a basic process control equipment and set proper parameters of its work		
Other social competences	Student is competent to apply automation		

Course title	INSTRUMENTAL ANALYSIS		
Level of course	second cycle		
Teaching method	lecturing course / laboratory course / lecture		
Person responsible for the course	Elwira Wróblewska	**E-mail address to the person**	Elwira.Wroblewska@zut.edu.pl
Course code (if applicable)	WTiICh-2-35	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	5	**Hours per semester**	75
Objectives of the course	Theoretical and practical learning about instrumental methods applied in quantitative and qualitative analysis; Theoretical studies about the phenomena used in the particular method as well as practical interpretation of the results given.		
Entry requirements	Basis of physical chemistry, organic chemistry, general chemistry, analytical methods.		
Course contents	The ways of preparing of the solution with a given concentration. The ways of expression of the content od some components of the solution. Units usually used in absorption spectra. The application of Lambert-Beer's low in quantitative analysis of single and multicomponent mixtures. Calibration curve and their application in quantitative analysis. The characteristic of the analytical method (limit of detection, method sensitivity and precision). The use of NMR spectroscopy in qualitative and quantitative analysis of organic compounds. The use of some information which are read off from chromatogram into qualitative and quantitative analysis of organic compounds Measurements of UV-vis spectra and their application in the studies of solute-solvent intermolecular interaction , as well as in quantitative analysis. The interpretation of HNMR spectra as a key to the determination of the structure of organic compounds. The application of IR method in qualitative and quantitative analysis of organic compounds. The application of chromatographic method in qualitative and quantitative analysis of multicomponent mixtures. The determination of some metals with the use of ASA method. The fundamental definitions concerning analytical process, the kind of analytical method with respect to instrumental method analysis. Classification of the methods of instrumental analysis, particularly spectroscopic and chromatographic ones. Explanation of wave-particle duality of electromagnetic radiation and influence of its absorption/emission by atom or molecule on their properties. Theoretical studies of phenomena proceeding in the molecule/atom under the irradiation and their application in particular methods i.e. ultraviolet-visual spectroscopy (UV-VIS), infrared spectroscopy (IR), nuclear magnetic resonance spectroscopy (NMR), mass spectroscopy (MS), atomic absorption spectroscopy (AAS), X-ray absorption, atomic emission spectroscopy (AES), flame photometry, inductively coupled plasma spectrometry (ICP), X-ray fluorescence (XRF), atomic fluorescence. Explanation of phenomena, concepts, and definitions used in chromatographic methods. The ways of separation of a mixture components.		
Assessment methods	The lectures with the discussion. Classes Laboratory Written exam and/or oral discussion. Assessment of laboratory written report. Assessment of homework assignments. Evaluation of the student’s work based on the student activity during the course.		
Recommended readings	1. J. M. Hollas, Modern spectroscopy, John Wiley, 2004 2. L.D. Field, S. Sternhall, J.R. Kalman, Organic structures from spectra, 3rd ed., Chichester, John Wiley and Son, 2002 3. J.R. Chapman, Practical Organic Mass Spectrometry, 2nd ed., Chichester, John Wiley and Son, 1993 4. Ira N. Levin, Molecular spectroscopy, Wiley-Interscience, New York, 1975 5. C. N. R. Rao, Ultra-violet and visible spectroscopy: chemical applications, 3rd ed., Butterworths, London, 1975 6. ed. D. A. Ramsay, Spectroscopy, University Park Press, London: Butterworths; Baltimore, 1976 7. Stefan Hüfner, Photoelectron spectroscopy: principles and applications, 2nd ed., Springer, Berlin, 1996		
Knowledge	Student knows the phenomena applied in the instrumental analysis. He has a knowledge about the fundamentals of the selected spectroscopic and chromatographic methods.		
Skills	Student is able to plan and carry out the experiment with the interpretation of obtained results.		

Other social competences	Student is able to choose the appropriate method in order to solve particular problem concerning qualitative and/or quantitative analysis

Course title	INTRODUCTION TO ORGANIC SYNTHESIS AND PRODUCTS ANALYSIS		
Level of course	second cycle		
Teaching method	lecturing course / laboratory course / lecture		
Person responsible for the course	Jacek Sośnicki	**E-mail address to the person**	Jacek.Sosnicki@zut.edu.pl
Course code (if applicable)	WTiICh-1-36	**ECTS points**	5
Semester	winter	**Language of instruction**	english
Hours per week	6	**Hours per semester**	90
Objectives of the course	The student knows the basic methods for construction of a carbon skeleton of organic compounds and has the fundamental knowledge on the methods of their analyses. The student demonstrates the ability to conduct the basic organic chemistry experiments and to analyze data and results by standard analytical methods. The student knows how to carry out a basic literature search based on databases and scientific literature. The student is aware of the importance of the knowledge acquired within the subject for developement of science and for impovement of the quality of life.		
Entry requirements	Basic knowledge of fundamental organic chemistry.		
Course contents	Exercises in planning the synthesis of organic molecules with the aid of databases. Exercises in determining the structure of organic compounds by IR, NMR, MS methods. Regulations and safety rules in the laboratory of organic chemistry. Basic and advanced laboratory equipment. Principles of laboratory raport preparation. Preparation of Grignard reagents (Schlenk technique) and their use in organic synthesis. Synthesis of tertiary alcohol, purification by vacuum distillation, and structure analysis by IR and NMR methods. Addition of C-nucleophiles to multiple carbon-carbon bonds. Eg. Addition of magnesiates to 2-pyridones. Determination of the reaction yield directly from the post-reaction mixture without isolation of the product. Isolation of the product by column chromatography and assignment its structure by IR, 1H and 13C NMR spectroscopy and MS analysis. Building a carbon skeleton by using palladium catalysts. Eg. Use of Sonogashira reaction in preparation of selected alkyne product. Purification with a properly selected method. Structure analysis by spectroscopic methods. Databases and scientific journals as a platform to start organic synthesis. Overview of IR, MS and NMR as fundamental methods for analysis of organic compounds. Practical notes. Selected new and old methods for building a carbon skeleton. Selected aspects of stereochemistry in organic synthesis Principles of planning the synthesis of complex molecules. Test.		
Assessment methods	Lecture with discussion. Laboratory exercises. Classes with discussion. Continuous assessment: laboratory reports and activity. Writting the final test.		
Recommended readings	1. J. J. Li, C. Limberakis, D. A. Pflum, Modern Organic Synthesis in the laboratory. A collection of standard experimental procedures, OXFORD University Press, 2007 2. John McMurry, Organic Chemistry, Brooks/Cole, 2012, 8e		
Knowledge	The studen has basic knowledge on structure, reactivity of simple organic compounds and on basic methods of their analyses.		
Skills	The studen is able to plan and perform basic synthetic transformations on the basis of informations taken from databases and scientific literature and is able to analyse the products by using basic analytical methods. The studen is able to prepare the basic laboratory raport.		
Other social competences	The student is aware of the importance of organic chemistry in life and science.		

Course title	INTRODUCTION TO RHEOLOGY		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Anna Story	**E-mail address to the person**	Anna.Story@zut.edu.pl
Course code (if applicable)	WTiICh-2-37	**ECTS points**	4
Semester	summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	The course aims to give a general introduction to the theory and practice of rheology		
Entry requirements	Chemical engineering fundamentals Applied Mathematics		
Course contents	Laboratories include experiments related to rheometric measurements of selected Newtonian and non-Newtonian systems at room temperature and high temperature, as well as descriptions of the results of rheometric measurements using mathematical models Introduction. Rheology and rheometry. Viscosity. Practical ranges of variables which affect viscosity. The shear-dependent viscosity of non-Newtonian liquids. Viscometers for measuring shear viscosity. Linear viscoelasticity. Normal stresses. Extensional viscosity. Rheology of polymeric liquids. Rheology of suspensions. Theoretical rheology. Written test.		
Assessment methods	Activating methods: lecture illustrated by multimedia presentation and didactic discussion Practical methods: laboratory exercises Lectures - written final test Laboratory - individual report after each laboratory		
Recommended readings	1. H.A. Barnes, J.F. Hutton, K. Walters, An Introduction to Rheology, Howard A. Barnes, John Fletcher Hutton, Kenneth Walters, Amsterdam, 1989, ISBN 0 444 87140 3 2. Thomas G. Mezger, The Rheology Handbook, Vincentz Network, 2011, 4th Edition, ISBN 978-3866308428		
Knowledge	Students will acquire detailed theoretical knowledge on many aspects within the framework of the rheology and rheometry		
Skills	Students will acquire practical knowledge on many aspects within the framework of the rheology and rheometry		
Other social competences	Students have the ability to solving and analyzing processes in the field of the rheology and rheometry. Students understand the needs of continuous training and development in the field of the rheology and rheometry		

Course title	ISOLATION AND CHARACTERIZATION OF NATURAL PRODUCTS FROM PLANTS		
Level of course	second cycle		
Teaching method	laboratory course		
Person responsible for the course	Małgorzata Dzięcioł	**E-mail address to the person**	Malgorzata.Dzieciol@zut.edu.pl
Course code (if applicable)	WTiICh-2-38	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Knowledge about isolation methods of natural products from plants. Knowledge about application of chromatographic and spectrophotometric methods to determination of composition and antioxidant activity of natural products isolated from plants.		
Entry requirements	Basics of analytical chemistry		
Course contents	Isolation of biologically active compounds from plant materials by different techniques including reflux extraction, ultrasound assisted extraction, Soxhlet extraction. Isolation of essential oils from plant materials by hydrodistillation method by using Deryng or Clevenger-type apparatus. Determination of the yields of essential oils. Analysis of essential oils and plant extracts composition by gas chromatography with mass selective detector method (GC-MS). Identification of the particular compounds on the basis of their retention times, retention indices and mass spectra. Analysis of antioxidant activity of extracts and essential oils by spectrophotometric method with DPPH radical. Determination of phenolic compounds by spectrophotometric method with Folin-Ciocalteu reagent.		
Assessment methods	Laboratory Consultations Evaluation of working in the laboratory Evaluation of written reports		
Recommended readings	1. Xu R., Ye Y., Zhao W. (ed.), Introduction to Natural Products Chemistry, CRC Press, Boca Raton, 2012 2. Sarker S.D., Latif Z., Gray A.I. (ed.), Natural Products Isolation, Humana Press, Totowa, New Jersey, 2006 3. McNair H.M., Miller J.M., Basic Gas Chromatography, Wiley, 2009, II edition		
Knowledge	Student has knowledge of isolation methods and analysis of natural products.		
Skills	Student is able to perform experiments using different methods of isolation of natural products from plants. Student is able to analyse the composition of natural products by gas chromatography method and determine their antioxidant activity using spectrophotometric methods.		
Other social competences	The student knows the importance of plants as natural sources of biologically active compounds.		

Course title	MACROMOLECULAR CHEMISTRY		
Level of course	second cycle		
Teaching method	lecture		
Person responsible for the course	Agnieszka Piegat	**E-mail address to the person**	Agnieszka.Piegat@zut.edu.pl
Course code (if applicable)	WTiICh-2-39	**ECTS points**	2
Semester	winter	**Language of instruction**	polish
Hours per week	2	**Hours per semester**	30
Objectives of the course	To acquaint students with the definitions and concepts related to the subject Developing the ability to use knowledge of the basic and specific problems of macromolecular chemistry Developing the skills to describe phenomena and physical models of large-molecule compounds		
Entry requirements	Knowledge in the field of physics, physical chemistry and polymer chemistry.		
Course contents	Introduction - monomers, units, polymers, oligomers, history of polymers, potential and real functionality, linear, branched and cross-linked structure, polydispersity, quantification of polydispersity of polymers. Dilute solutions of polymers - swelling and dissolving, thermodynamics of dissolution, Hildebrand parameters, close and long range macromolecules interactions, Kuhn statistical model, probability of finding the end of a chain in volume, probability of the distance of the ends of the chain. Coil size, coil expansion coefficient, theta conditions, metastable solutions, polymer-solvent interaction coefficient, dimensions of macromolecules branched, solubility of high-molecular biopolymers. Viscosity of diluted polymer solutions and the method of determination of the viscometric mean molecular weight (viscosity definition, reduced viscosity, significant, MKSH equation, dimensions macromolecules, intrinsic viscosity and molecular weight relationship, Flory-Fox formulas, determination of K and alpha in MKSH formulas, concentration dependence of the intrinsic viscosity, molar coefficient of friction). Analytical methods for determining the molecular weight distribution function of polymers - turbidimetric titration method, thin layer chromatography method, GPC method, ultracentrifuge method. Other methods of determining the heterogeneity of polymers. Method for determining the numer and weight average molecular weight of a polymer - light scattering in polymer studies; osmometric methods, diffusion methods.		
Assessment methods	Lecture writing exam Note for activity during classes		
Recommended readings	1. J.M.G. Cowie, Polymers: Chemistry & Physics of Modern Materials, 2nd ed,, Blackie Academic & Professional, 1996 2. Sun, Siao F., Physical chemistry of macromolecules : basic principles and issues, Hoboken : John Wiley & Sons, cop., 2004 3. Arridge, Robert G. C., Behavior of macromolecules, Berlin : Springer-Verlag, 1982 4. L. H. Sperling, Introduction to physical polymer science, Wiley-Interscience, New York, 1992		
Knowledge	The student should define, explain and translate the concepts in the field of macromolecular chemistry of polymers. Student should be able to characterize models and phenomena related to macromolecular compounds. The student is able to describe and explain the behavior macromolecules in solutions and can characterize molecular properties of them.		
Skills	The student is able to interpret and quantify the phenomena in macromolecular solutions as well as on the basis of theoretical knowledge, is able to select appropriate methods for characterizing macromolecules in solutions. Student is able to supplement the information obtained during the lectures about the content contained in the literature on the subject.		
Other social competences	student shows an active attitude during lectures and exam, takes care of linguistic correctness related to terminology the item.		

Course title	MASS TRANSFER		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Maciej Konopacki	**E-mail address to the person**	mkonopacki@zut.edu.pl
Course code (if applicable)	WTiICh-2-40	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	The student will be able to: 1.Identify and understand the various mechanisms of mass transfer. 2.Formulate basic equation for mass transfer problems. 3.Use of experimentally derived correlations for estimating mass transfer coefficient for a variety of flow situations. 4.Apply mass transfer principles to design mass transfer equipment.		
Entry requirements	Fundamentals of chemical engineering Physics Mathematics		
Course contents	Calculations of molecular diffusion. Calculations of convective mass transfer. Calculations of simultaneous heat and mass transfer. Calculations of mass exchangers. Simulation of mass exchangers using Aspen. Introduction. Molecular diffusion. Convective mass transfer: laminar and turbulent. Simultaneous heat and mass transfer. Interface mass transfer. Mass exchanger: type of equipment. Mass exchanger calculations. Design of mass exchanger.		
Assessment methods	Lecture illustrated by Power Point presentation and computer simulation Classis illustrated by computer and manual calculations Periodic assessment of student achievement Lecture: exam at the end of the semester Classis: written test		
Recommended readings	1. Incropera F.P., Lavine A.S., DeWitt D.P., Fundamentals of Heat and Mass Transfer, Wiley, New York, 2011 2. Hines A.L., Maddox R.N., Mass transfer: fundamentals and applications, Prentice-Hall, New Jersey, 1985 3. Cussler E.L., Diffusion: mass transfer in fluid systems, Cambridge University Press, New York, 1997		
Knowledge	The student will be able to identify and understand the various mechanisms of mass transfer.		
Skills	The student will be able to: 1.Formulate basic equation for mass transfer problems. 2.Use of experimentally derived correlations for estimating mass transfer coefficient for a variety of flow situations.		
Other social competences	The student will be able to apply mass transfer principles to design mass transfer equipment.		

Course title	MATERIALS SCIENCE IN CHEMICAL ENGINEERING		
Level of course	second cycle		
Teaching method	lecture		
Person responsible for the course	Rafal Pelka	**E-mail address to the person**	Rafal.Pelka@zut.edu.pl
Course code (if applicable)	WTiICh-2-41	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	The objective of this course is to provide essential concepts in material science with an emphasis on selected solids, their behavior and processing in various chemical engineering operations. To provide material engineering and chemical engineering training for students whose backgrounds do not include a B.S. degree in chemical engineering. To develop competence to analyze and solve material engineering and chemical engineering problems making use of principles of thermodynamics and kinetics.		
Entry requirements	Mathematics Physics Physical chemistry Inorganic chemistry Fundamentals of chemical engineering		
Course contents	Strength of materials - basic concepts Strength of materials - strength tests of construction materials Strength calculations - examples of applications Metallography - general information Phase transitions - solidification, melting, zone refining, phase diagrams Iron alloys structure - iron-carbon phase diagram Thermo- and thermo-chemical treatment of iron and iron-carbon alloys (phase diagrams and industrial examples) Specialty steels Nonferrous Alloys Construction Materials Electronic Materials Ceramic Materials Magnetic Materials Polymers: Classification of polymers; Addition and condensation polymerization; Degree of polymerization; Characterization of thermoplastics; Characterization of elastomers; Thermosetting polymers; Polymer processing and Recycling Composites: Dispersion-strengthened composites ; Particulate composites; Fiber-reinforced composites; Laminar composite materials; Sandwich structures Final test		
Assessment methods	informative lecture conversational lecture clasroom discussion demonstrating Test Activity assessment Test		
Recommended readings	1. François Cardarelli, Materials Handbook A Concise Desktop Reference, Springer International Publishing AG, 2018 2. Mukai Kusuhiro, Matsushita Taishi, Chemical thermodynamics in materials science : from basic to practical applications, Axel Springer Verlag, Singapore, 2018 3. William D. Callister, jr., David G. Rethwisch, Fundamentals of materials science and engineering : an integrated approach, John Wiley & Sons, Singapore, 2016 4. Traugott Fischer, Materials science for engineering students, Elsevier: Academic Press, Amsterdam, 2009 5. William D. Callister, Jr. ; with special contributions by David G. Rethwisch, Materials science and engineering : an introduction, John Wiley & Sons, New York, 2007 6. Sebastian Koltzenburg, Michael Maskos, Oskar Nuyken, Polymer Chemistry, Springer, 2017 7. Krishan K. Chawla, Composite Materials, Springer, 2012 8. Xiao-Su Yi, Shanyi Du, Litong Zhang, Composite Materials Engineering, Volume 1, Springer, 2018 9. Xiao-Su Yi, Shanyi Du, Litong Zhang, Composite Materials Engineering, Volume 2, Springer, 2018		

Knowledge	Student knows essential concepts in material science with an emphasis on selected solids, their behavior and processing in various chemical engineering operations.
Skills	Student will be able to apply the acquired skills and knowledge on material science and chemical engineering to comprehend, describe and resolve selected material and chemical engineering problems.
Other social competences	Student will be competent to analyze and solve material engineering and chemical engineering problems making use of principles of thermodynamics and kinetics.

Course title	MEMBRANE PROCESSES		
Level of course	second cycle		
Teaching method	lecture		
Person responsible for the course	Sylwia Mozia	**E-mail address to the person**	Sylwia.Mozia@zut.edu.pl
Course code (if applicable)	WTiICh-2-42	**ECTS points**	1
Semester	winter/summer	**Language of instruction**	english
Hours per week	1	**Hours per semester**	15
Objectives of the course	Student will get theoretical knowledge on membranes and membrane processes and their applications. The main issues to be discussed during the lectures include (i) polymeric and ceramic membranes: properties and preparation, (ii) basics of pressure driven, concentration driven and electrically driven techniques, and (iii) examples of applications of membrane technology in industry and environment.		
Entry requirements	Fundamentals of chemistry and chemical technology/engineering.		
Course contents	Introduction to membrane processes. Definitions. Membranes and membrane modules: definitions, division, preparation, properties. Pressure driven membrane techniques (microfiltration, ultrafiltration, nanofiltration, reverse osmosis) Concentration driven membrane processes (dialysis, pervaporation, membrane distillation) Electrically driven membrane processes (electrodialysis, electrodialysis reversal) Membrane reactors		
Assessment methods	lecture class test/grade		
Recommended readings	1. Heinrich Strathmann, Introduction to Membrane Science and Technology, John Wiley & Sons, 2011 2. Marcel Mulder, Basic Principles of Membrane Technology, Springer Science & Business Media, 2013 3. Richard W. Baker, Membrane Technology and Applications, John Wiley & Sons, 2004 4. Norman N Li, Anthony G. Fane, W. S. Winston Ho, Takeshi Matsuura, Advanced Membrane Technology and Applications, John Wiley & Sons, 2011		
Knowledge	At the completion of this course, students will be able to: - Present definisions and bascis laws related to membranes and membrane processes. - Explain differences between membrane processes operated under various driving forces. - Describe industrial and environmental applications of membrane technology.		
Skills	At the completion of this course, students will be able to: - Analyze and propose membranes for process design. - Analyze and propose membrane technology for environmental and industrial applications.		
Other social competences	Student understands the needs of continuous training and development in the field of membranes and membrane processes.		

Course title	METHODS OF ORGANIC COMPOUNDS IDENTIFICATION		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Elwira Wróblewska	**E-mail address to the person**	Elwira.Wroblewska@zut.edu.pl
Course code (if applicable)	WTiICh-2-43	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	To gain the knowledge about the methods of organic compounds identification.		
Entry requirements	Fundamentals of physical chemistry. Fundamentals of organic chemistry		
Course contents	The recording and interpretation of IR spectra od various organic compounds. The analysis of NMR spectra of organic compounds. The analysis of MS spectra of various group of organic compounds. The application of the chromatographic method in qualitative analysis of various compounds. Classification of the methods of qualitative analysis of organic compounds, especially spectroscopic and chromatographic ones. Explanation of theoretical fundamentals of the interaction of electromagnetic radiation with an atom or molecule. Application of selected methods i.e. ultraviolet-visual spectroscopy (UV-VIS), infrared spectroscopy (IR), nuclear magnetic resonance spectroscopy (NMR), mass spectroscopy (MS), atomic absorption in qualitative analysis of various compounds. Explanation of phenomena, concepts, and definitions used in chromatographic methods. Application of chromatographic methods in qualitative analysis of organic compounds.		
Assessment methods	The lectures with the discussion. Laboratory Written exam and/or oral discussion Assessment of laboratory written report Evaluation of the student’s work based on the student activity during the course.		
Recommended readings	1. Field, L. D, Strnhell, S, Kalman, J.R., Organic structures from spectra, Chichester : John Wiley and Sons, 2002 2. Láng, L., Holly, S, Sohár, P., Absorption spectra in the infrared region., Akadémiai Kiadó,, Budapest, 1980 3. Perkampus, Heinz-Helmut., Encyclopedia of spectroscopy, Weinheim : VCH, 1995 4. Rahman, Atta-ur, One and two dimensional NMR spectroscopy, Elsevier, Amsterdam, 1989 5. J.R. Chapman, Practical Organic Mass Spectrometry, 2nd ed., Chichester: John Wiley and Son, 1993 6. Sliwiok, Józef,, Chromatography in physico-chemical investigations of organic compounds, Uniwersytet Slaski,, Katowice, 1985 7. ed. F. A. A. Dallas, Thin-layer chromatography-recent advances., Chromatographic Society;, London : Plenum, New York, 1988		
Knowledge	Student has a knowledge about the selected method of organic compounds identyfication.		
Skills	Student is able to plane and carry the experiment with the interpretation of obtained results.		
Other social competences	Student is able to choose the appropriate method in order to solve particular problem concerning quantitative analysis.		

Course title	MODELING AND SIMULATION IN CHEMICAL ENGINEERING		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Anna Story	**E-mail address to the person**	Anna.Story@zut.edu.pl
Course code (if applicable)	WTiICh-2-44	**ECTS points**	4
Semester	summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The student will be able to: 1. Develop of process models based on conservation laws and process data. 2. Use computational techniques to solve the process models. 3. Use simulation tools such as MATLAB, POLYMATH, and ASPEN PLUS.		
Entry requirements	Mathematics. Fundamentals of chemical engineering.		
Course contents	Analysis of experimental results. Nonlinear parameter estimation. Development of exemplary mathematical models. Modelling and simulation of selected chemical engineering systems using MATLAB, POLYMATH, CFD and ASPEN PLUS. Analysis of experimental results. Nonlinear parameter estimation. Dimensional analysis. Scaling. Mathematical model development. Synthesis of sub-models. Classification of models: deterministic, stochastic, lumped and distributed parameter. Modelling and simulation techniques. Population balance models. Microbial population. Monte Carlo methods. Nonlinear dynamics and chaos.		
Assessment methods	Lecture illustrated by Power Point presentation and computer simulation Classis illustrated by computer and manual calculations Periodic assessment of student achievement Lecture: exam at the end of the semester Classis: written test		
Recommended readings	1. Hangos K.M., Cameron L.T., Process modelling and model analysis, Academic Press, San Diego, 2001 2. Rice R.G., Do D.D., Applied mathematics and modeling for chemical engineers, Wiley, New York, 2011 3. Finlayson B.A., Introduction to chemical engineering computing, Wiley, New York, 2005		
Knowledge	The student will be able to develop of process models based on conservation laws and process data.		
Skills	The student will be able to use computational techniques to solve the process models.		
Other social competences	The student will be able to use simulation tools such as MATLAB, POLYMATH, and ASPEN PLUS.		

Course title	MULTIPHASE FLOWS		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Anna Kiełbus-Rąpała	**E-mail address to the person**	Anna.Kielbus-Rapala@zut.edu.pl
Course code (if applicable)	WTiICh-2-45	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	The course aims to give a general introduction to the theory of multiphase flow and to provide the necessary theoretical basis for design of multiphase pipelines.		
Entry requirements	Introduction to physical chemistry		
Course contents	Project of simple installation with multiphase flow Introduction to multiphase flows (classifications of multiphase systems, review of fundamentals of transport phenomena, vectors and tensors, equations of motion, interaction with turbulence) Two-phase flow (definitions, flow patterns in vertical and horizontal tubes, two-phase flow models) Distribution of particle and droplets sizes (discrete and continuous size distributions, statistical parameters, interactions of fluids with particles, drops and bubbles) Cavitation. Boiling and condensation. Aerosol flows. Spray system. Dry powder flows. Granular flows Multiphase flows in pipes: flow regime maps, concentration distributions and pressure drop Multiphase flows in agitated vessels (gas-liquid systems, solid – liquid systems, gas-solid-liquid systems) Equipment for multiphase flows in agitated vessels and static mixers Fluidized beds (hydrodynamics of fluidization, flow regimes and their transitions, particulate and bubble-free fluidization, slugging fluidization, turbulent fluidization) Particle separation systems (separation efficiency and grade efficiency, classification of particle separation systems, flow-through type separator, gravitational collectors, centrifugal separation) Pneumatic conveying (background, flow patterns in gas-solid systems, classification of bulk solids (Geldart classification)) Slurry flows (basic concepts of slurry flows, slurry flow regimes, homogeneous flow of non-settling slurries (rheological models for Newtonian and non-Newtonian slurries), pressure loss through straight circular pipe Micro-scale flows (gas-liquid two-phase flow in micro-channels, two-phase flow patterns, mini-channels, micro-channels, effect of surface contamination, void fraction pressure drop)		
Assessment methods	Lecture illustrated by Power Point presentation Projects method written test completion of the project based on the correctly performed project computations		
Recommended readings	1. Brennen Ch.E., Fundamentals of Multiphase Flow, Cambridge University Press, Cambridge, 2005 2. Crowe C.T. (Ed.), Multiphase flow handbook, CRC Press, Boca Raton, 2006 3. Faghri A., Zhang Y., Transport Phenomena in Multiphase Systems, Elsevier Academic, Boston, 2006 4. Perry's Chemical Engineers' Handbook, McGraw-Hill, New York 2007., McGraw-Hill, New York, 2007		
Knowledge	to give a detailed knowledge about multiphase flows		
Skills	student has ability to calculate and solve different practical problems on multiphase flows		
Other social competences	student understands the needs of continuous training and development in the field of multiphase flows		

Course title	NANOPARTICLES AND ENVIRONMENT		
Level of course	second cycle		
Teaching method	lecture		
Person responsible for the course	Beata Tryba	**E-mail address to the person**	Beata.Tryba@zut.edu.pl
Course code (if applicable)	WTiICh-2-46	**ECTS points**	2
Semester	winter/summer	**Language of instruction**	english
Hours per week	1	**Hours per semester**	15
Objectives of the course	Come to know about the influence of nanotechnology and nanoparticles on the human life and environment; regulations about management of the nanomaterials; risk assesment of the nanoparticles effect on the human body; determination of nanoparticles in the environment; analyses methods of nanoparticles present in different media; analysis of nnoparticles life cycle in the environment and their risk		
Entry requirements	Fundamentals of materials chemistry		
Course contents	Introduction to the nanoparticles and nanotechnologies Toxicity and ecotoxicity of nanoparticles in the environment Risk assesments of nanoparticles in the environment – analytical methods Nanoparticles in the consumer products Impact of nanoparticles on the human body Nanotechnologies – benefits and risks Risk assesment of nanoparticles in the environment – computional modelling methods QSAR (Quantitative Structure-Activity Relationships) Nanotechnology - Policy and Regulations WHO Guidelines on Protecting Workers from Potential Risks of Manufactured Nanomaterials Nanotechnologies and societies in Japan, USA, Europe Nanotechnologies and ethical issues Summary		
Assessment methods	lecture discussion presentation performed by student related to the studied topic test/ grade		
Recommended readings	1. Ecotoxicology, Springer, 2008, 17 2. G. Hunt, M. Mehta, Nanotechnology. Risk, Ethics and Law 3. J. C. Miller, R. Serrato, J. M. Represas-Cardenas, G. Kundahl, The Handbook of Nanotechnology. Business, Policy, and Intellectual Property Law		
Knowledge	Participant of this course will get knowledge and wide awarness on the presence of nanoparticles in the commercial products and their distribution pathway to environment. This knowledge will involve also the impact of the nanoparticles on the animals and humans health, their toxicity and way of safety handling. The student will be informed about the present regulations in the European Union and whole the world about handling the nanoparticles and nanoproducts.		
Skills	The student would be able to easy recognize products obtained though the nanotechnology and will be aware the risk of using it and deposition in the environment according to the estimation of whole cycle of life. The student will be able to apply the proper methods of identification and measurements of nanoparticles in the environment.		
Other social competences	Student will be aware of danger during exposition to nanoparticles and will know how to protect the human body and surrounding environment against this danger; will be able to apply the proper protection resources in the laboratory and the place of work. Student will be aware of the ethical issues connected with using of some nanotechnology products.		

Course title	ORGANIC COATINGS		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Krzysztof Kowalczyk	**E-mail address to the person**	Krzysztof.Kowalczyk@zut.edu.pl
Course code (if applicable)	WTiICh-2-47	**ECTS points**	4
Semester	summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	To gain the knowledge of technology (preparation, modification) and application of nano- and microcomposite organic varnishes (decorative, protective, special type), paints and coatings		
Entry requirements	Chemical technology, chemical engineering, polymer technology		
Course contents	Preparation of solvent-borne and water-borne varnishes and paints. Application of varnishes and paints Testing of varnish and paint coatings Definitions of a varnish, paint, adhesive, binder, film forming substance, pigment, micro- and nanofiller, solvent, diluent. Characterization of the most popular binders, micro- and nanofillers, pigments (decorative, anticorrosive), solvents and coating additives. Preparation principles of solventless, solventborne, powder as well as waterborne coating compositions, including nanocomposite systems. Application methods of coating compositions. Testing techniques of liquid and dry/cured coating compositions.		
Assessment methods	lecture examination		
Recommended readings	1. J. Koleske, Paint and coating testing manual, ASTM, Philadelphia, 1995 2. Koo JH, Polymer nanocomposites, The McGraw-Hill Comp., New York, 2006 3. 2. Z. Wicks, F. Jones, Organic coatings, John Wiley&Sons, Hoboken, 2007		
Knowledge	To gain detailed theoretical knowledge of coating materials		
Skills	To gain practical knowledge/skills of coating materials		
Other social competences	Student understands the importance of technical application of coating materials		

Course title	PARTICULATE TECHNOLOGY		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Anna Story	**E-mail address to the person**	Anna.Story@zut.edu.pl
Course code (if applicable)	WTiICh-2-48	**ECTS points**	3
Semester	summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	The student will be able to: 1. Understand and apply the theoretical fundamentals of particle technology in chemical engineering. 2. Understand the experimental methods necessary to characterize the properties of particles and powders. 3. Understand the hydrodynamics of gas-solid systems.		
Entry requirements	Fundamentals of chemical engineering Physics		
Course contents	Particle size analysis. Motion of solid particles in a fluid. Fluid flow through a packed bed. Filtration. Fluidization. Separation of particles from a gas. Mixing and segregation of particles. Particle characterization. Particle size analysis. Motion of solid particles in a fluid. Multiple particle systems. Colloids and fine particles. Fluid flow through a packed bed. Filtration. Fluidization. Pneumatic transport. Separation of particles from a gas. Mixing and segregation of particles. Particles size reduction. Particles mechanics. Discharge of particulate bulk solids. Storage and flow of powders.		
Assessment methods	Lecture illustrated by Power Point presentation and computer simulation Classis illustrated by computer and manual calculations Periodic assessment of student achievement Lecture: exam at the end of the semester Classis: written test		
Recommended readings	1. Rhodes M., Introduction to Particle Technology, Wiley, Chichester, 2008 2. Aste T., Tordesillas A., Di Matteo T. (Editors), Granular and complex materials, World Scientific Publishing, London, 2007 3. Particles, bubbles and drops-their motion, heat and mass transfer, World Scientific Publishing, London, 2006		
Knowledge	The student will be able to understand the theoretical fundamentals of particle technology.		
Skills	The student will be able to apply the particle technology in chemical engineering.		
Other social competences	The student will be able to understand the hydrodynamics of gas-solid systems.		

Course title	PHARMACEUTICAL CHEMISTRY		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Paula Ossowicz	**E-mail address to the person**	Paula.Ossowicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-49	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	Student has knowledge about drug discover, sources of drugs and lead compounds, classification of drugs and drug action. Student can synthesis different active substances (drugs).		
Entry requirements	Basics of organic compound and biochemistry.		
Course contents	Synthesis of 2-3 products by standard processes in pharmaceutical chemistry. Isolation of products from natural sources Qualitative analysis of pharmaceutical products A brief history of drugs: from plants extracts to DNA technology Sources of drugs and lead compounds Classification of drugs Introduction to drug action Drug Development and Production		
Assessment methods	lectures laboratory wtritten exam written report, grade		
Recommended readings	1. Gareth Thomas, Medicinal Chemistry An Introduction, John Wiley & Sons Ltd,, Chichester, England, 2007, Second Edition 2. Camille Georges Wermuth, The Practice of Medicinal Chemistry, Elsevier, Oxford, England, 2003, Second Edition 3. Pharmaceutical Chemistry, David G. Watson, Elsevier, 2011 4. Gareth Thomas, Fundamentals of Medicinal Chemistry, John Wiley & Sons Ltd,, Chichester, England, 2003		
Knowledge	Student will have knowledge about drugs, their classification, types of drugs, sources and drug action.		
Skills	The student will be able to obtain simple compounds with pharmaceutical activity.		
Other social competences	Student is able to indicate by-products and waste substances arising in the production process of selected groups of drugs and their impact on the quality of drugsand the ways of their elimination.		

Course title	PHOTOCATALYSIS FOR ENVIRONMENTAL APPLICATION		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Ewelina Kusiak-Nejman	**E-mail address to the person**	Ewelina.Kusiak@zut.edu.pl
Course code (if applicable)	WTiICh-2-50	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The course is aimed at giving an overview of photocatalysis and related processes for environmental application. Student will be able to define basic processes, including photocatalysis, excitation of semiconductors, etc. Student will be able to know the mechanisms of photocalytic processes, as well as mechanisms of photocatalytic degradation of inorganic and organic pollutants from water and wastewater. Student will be able to know the mechanisms of photocatalytic processes, as well as mechanisms of photocatalytic degradation of inorganic and organic pollutants from air. Student will be able to know the mechanisms of photosensibilization. Student will be able to know the application of photocatalytic processes in real life.		
Entry requirements	The basic knowledge of basic safety rules. Basic knowledge in the field of inorganic chemistry. Basic knowledge in the field of properties of inorganic oxides.		
Course contents	Photocatalytic degradation of organic dyes from water under UV and UV-Vis light Photocatalytic oxidation of nitric oxide in the presence of titnium dioxide and zinc oxide. Photocatalytic inactivation of bacteria cells contained in water and wastewater. Photocatalytic inactivation of microorganisms contained in air. Removal of dyes and exemplary VOCs in the presence of photocatalytic paints. Fundamentals of photocatalysis Mechanism of photocatalytic excitation of the semidonductors Materials in photocatalysis Photocatalytic oxidation of organic pollutants from water and wastewater Photosensibilazation Photocatalytic oxidation of air pollutants Photocatalytic disintection of water Bioaerozols inactivation from air utilizing photocatalysis Photocatalysis in real life - application of photocatalytic products Photocatalytic paints with self-cleaning properties		
Assessment methods	Lectures Discussion with the teacher Final written test - lectures Preparation of laboratory reports - laboratory classes A test to check preparation for laboratory activities - laboratory classes		
Recommended readings	1. Yuvaraj M. Hunge, Anuja A. Yadav, Basics and advanced developments in photocatalysis – a review, International Journal of Hydrology, 2018, 2(4), 10.15406/ijh.2018.02.00122 2. J. Xuan, W.-J. Xiao, Visible-Light Photoredox Catalysis, Angew. Chem. Int. Ed., 2012, 51, pages 6828–6838 3. J. Xing, W. Q. Fang, H. J. Zhao, H. G. Yang, Inorganic Photocatalysts for Overall Water Splitting, Chem. Asian J., 2012, 7, pages 642–657 4. D.Sudha, P.Sivakumar, Review on the photocatalytic activity of various composite catalysts, Chemical Engineering and Processing: Process Intensification, 2015, 97, pages 112-133 5. Junhua You, Yaozu Guo, Rui Guo, Xuanwen Liu, A review of visible light-active photocatalysts for water disinfection: Features and prospects, Chemical Engineering Journal, 2019, 373, pages 624-641		
Knowledge	As a result, the student should be able to define basic concepts related to photocatalysis. As a result of the classes, the student should be able to explain the mechanisms of photocatalysis in water solution or suspension. As a result of the classes, the student should be able to list the materials used in the photocatalytic purification of water and wastewater. As a result of the classes, the student should be able to explain the mechanisms of photocatalytic degradation of organic and inorganic pollutants, inactivation of microorganisms and photosensibilzation, removal of bioaerozols from air, as well as air cleaning from VOCs. As a result, the student should be able to know the routes of application of photocatalysis in environmental application.		
Skills			

	As a result of the classes, the student should know how to interpret the results of photocatalytic degradation processes of organic pollutants. As a result of the classes, the student should know how to calculate the efficiency of the degradation of contaminants utilizing adsorption and photocatalytic process. As a result of the classes, the student should know how to prepare laboratory reports containing results and conclusions.
Other social competences	As a result of the conducted classes, the student will acquire the following attitudes: caring for the environment, openness to changes related to the water and air contamination, acting in accordance with the rules of ethics, awareness the results of water and air contamination as a global aspect.

Course title	PHYSICAL CHEMISTRY OF SURFACES		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Dariusz Moszyński	**E-mail address to the person**	Dariusz.Moszynski@zut.edu.pl
Course code (if applicable)	WTiICh-2-51	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Student knows the structure of surfaces and interfaces Student knows fundamental laws applicable to the processes performed on the surfaces of solids Student knows the basic experimental methods applied to evaluate the properties of solid surfaces and is able to perform respective experiments		
Entry requirements	Inorganic and organic chemistry Physical chemistry		
Course contents	Analysis of macro- and microporous materials Chemical composition of surfaces: x-ray photoelectron spectroscopy Transmission and scanning electron microscopy Materials of developed surface Surfaces and interfaces Electrical, mechanical and optical properties of surfaces Surface phenomena. Sorption processes. Adsorption and desorption Chemical reactions on surfaces. Solid – gas reactions The techniques of surface science		
Assessment methods	Lecture Laboratory Exam		
Recommended readings	1. G.A. Somorjai, Introduction to surface chemistry and catalysis, Wiley, 1994 2. John C. Vickerman, Ian S. Gilmore, Surface analysis: the principal techniques, Wiley, 2009		
Knowledge	Student knows the structure of surfaces and interfaces		
Skills	is able to perform respective experiments		
Other social competences	Student is competent in ohysical chemistry of surfaces		

Course title	POLYMER CHEMISTRY		
Level of course	second cycle		
Teaching method	lecture		
Person responsible for the course	Mirosława El Fray	**E-mail address to the person**	Miroslawa.ElFray@zut.edu.pl
Course code (if applicable)	WTiICh-2-52	**ECTS points**	2
Semester		**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	The course is aimed at giving an introduction to polymer chemistry. Student will be able to define basic terms related to polymer synthesis and properties, will be able to select materials for particular applications according the applications requirements. Student will be able to work in a group and will be able to broaden her/his knowledge in the field.		
Entry requirements	none		
Course contents	Basic definitions in polymer chemistry Molecular masses and macromolecular architectures Basic mechanisms in polymer reactions Synthesis methods in polymer chemistry Synthesis and applications of polyolefines: polyethylene and polypropylene Synthesis and applications of polyesters: PET, PBT Synthesis and applications of polyamides: PA6 and PA6,6 Synthesis and applications of polyurethanes Synthesia dn applications of high performance polymers: PEEK, PES Synthesis and applications of thermoplastic elastomers		
Assessment methods	lecture examination/presentation of a topic formulated by the supervisor		
Recommended readings	1. Davis F.J., Polymer chemistry, Oxford University Press, Oxford, 2004 2. Cheremisinoff N.P., Polymer characterization, Noves Pub., New York, 1996		
Knowledge	To provide a detailed theoretical knowledge within the field of polymer chemistry		
Skills	To provide a practical knowledge within the framework of polymer chemistry		
Other social competences	To provide basic competences in knowledge on polymer praparation, characterization and applications		

Course title	POLYMER COMPOSITES		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Krzysztof Kowalczyk	**E-mail address to the person**	Krzysztof.Kowalczyk@zut.edu.pl
Course code (if applicable)	WTiICh-2-53	**ECTS points**	4
Semester	winter	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	To gain the knowledge, skills and competences in the field of: - composition of polymer composites, - preparation and testing methods of polymer composites, - properties and application of polymer composites.		
Entry requirements	Chemical technology, chemical engineering, polymer technology		
Course contents	Preparation of polymer composites via a casting method Preparation of polymer laminates Preparation of polymer composites via compression moulding of BMC Preparation of polymer-concrete composites Preparation of polymer composite via an extrusion method Characterisation of the prepared polymer composites Basic information about polymers and composite materials Polymeric matrices for composite materials (selected thermoplastics, epoxy resins, unsaturated polyester resins, phenoplasts) Reinforcing agents and spacers for polymer micro- and nanocomposites (fibers, micro- and nanosized powders, core layers/structures) Preparation methods of polymer-based composites Selected testing methods of composite materials		
Assessment methods	Lecture Laboratory classes Continuous assessment during laboratory classes Reports Exam		
Recommended readings	1. Marino Xanthos, Functional fillers for plastics, Wiley, Weinheim, 2005 2. D. Gysau, Fillers for paints, Vincentz, Hannover, 2006 3. J.-P. Pascault (ed.), Epoxy polymers, Wiley, Weinheim, 2010 4. F. Bergaya, B.K.G. Theng, G. Lagaly, Handbook of clay science, Elsevier, Amsterdam, 2006 5. Z. Wicks, Organic coatings, J. Wiley & Sons, Hoboken, 2007 6. A. B. Morgan, C. A. Wilkie, Flame retardant polymer nanocomposites, J. Wiley, Hoboken, 2007 7. Y. W. Mai, Z.Z. Yu, Polymer nanocomposites, CRC Press, Boca Raton, 2006 8. B. P. Grady, Carbon nanotube-polymer composites, J. Wiley, Hoboken, 2011 9. Koo JH, Polymer nanocomposites, The McGraw-Hill Comp., New York, 2006		
Knowledge	To gain detailed theoretical knowledge of composition, preparation and characterisation of polymer composite materials		
Skills	To gain practical knowledge/skills in the field of composition, preparation and characterisation of polymer composite materials		
Other social competences	To gain competences in the field of an influence of polymer composite materials on individual life aspects		

Course title	POLYMER TESTING		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Krzysztof Kowalczyk	**E-mail address to the person**	Krzysztof.Kowalczyk@zut.edu.pl
Course code (if applicable)	WTiICh-2-54	**ECTS points**	4
Semester	summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	To gain the knowledge, skills and competences in the field of: - characterisation of components of polymeric materials; - characterisation of polymeric materials.		
Entry requirements	Polymer technology		
Course contents	Testing of selected components of polymeric materials Testing of selected rheological and mechanical features of polymeric materials Testing of selected thermal features of polymeric materials Testing of selected features of varnishes, paints, adhesives as well as composites, coatings, and adhesive joints Basic information about polymers, polymeric materials components and polymer composite materials Testing methods of components of reactive polymeric compositions, polymer composites, coatings, adhesives and foamed polymeric materials Main testing methods of mechanical features of polymeric materials Main testing methods of thermal features of polymeric materials Main testing methods of optical, electrical, electrochemical and barrier features of polymeric materials		
Assessment methods	Lecture Laboratory classes Continuous assessment during laboratory classes Reports Exam		
Recommended readings	1. D. Gysau, Fillers for paints, Vincentz, Hannover, 2006 2. E. Petrie, Epoxy adhesive formulations, Mc Grew Hill, New York, 2006 3. J. Koleske, Paint and coating testing manual, ASTM, Filadelfia, 1995, 14-th 4. Koo JH, Polymer nanocomposites, The McGraw-Hill Comp., New York, 2006 5. -, EN-ISO standards, International Organization for Standardization, and other, -		
Knowledge	To gain detailed theoretical knowledge in the field of characterisation of polymeric materials and their components		
Skills	To gain practical knowledge/skills in the field of characterisation of polymeric materials and their components		
Other social competences	Student understands the technical importance of characterisation methods and features of polymeric materials		

Course title	PRINCIPLES OF ANALYTICAL CHEMISTRY		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Zbigniew Rozwadowski	**E-mail address to the person**	Zbigniew.Rozwadowski@zut.edu.pl
Course code (if applicable)	WTiICh-2-55	**ECTS points**	3
Semester	summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Application of an appropriate analytical techniques depending on the sample type and matrix. Explanation of the construction of analytical instrumentation and indications the possibility of its application. Correct interpretation of the results of analytical determinations. Writing of reports on the analytical results.		
Entry requirements	The basic knowledge of fundamental and inorganic chemistry as well as basic safety rules		
Course contents	Occupational health and safety in the laboratory. Calibration of volumetric glassware: calibration of a buret Acid-base titrimetry. Preparation of 0.1 M HCl solution Standardization of 0.1 HCl solution with sodium carbonate. Acid-base titrimetry. Preparation of 0.1 M NaOH solution. Standardization of 0.1 NaOH solution. Titration of HCl solution Conductometry. Conductometric titratiof of HCl Reduction-Oxidation Titrations. Preparation of 0.1 M potassium permanganate solution Standardization of a 0.1 M potassium permanganate solution solution with sodium oxalate. Determination of Fe in sample. Complexometric methods. Determination of total hardness of water Gravimetric methods. Determination of chlorides (Mohr method) Basic tool in analytical chemistry (measurements, concentration, stock solution, basic equippment, etc.). Analytical methods (accuracy, selectivity, sensitivity, experimental errors, statistical analysis of data). Standarizing analytical methods. Preparation of samples. Titrametic methods (acid-base, complexation, redox, precipitation). Gravimetric methods. Spectroscopic methods (UV-Vis, IR, NMR, etc.). Chromatographic methods (GC, HPLC). Electrochemical methods: introduction to electrochemistry, conductometry, potentiometry, amperometry and voltametry.		
Assessment methods	Lecture Discussion Labs Written exam (lecture) Continuous assessment: lab reports and activity (labs)		
Recommended readings	1. Harvey D., Modern analytical chemistry, McGraw-Hill Companies Inc., 2000, open access 2. Curreli, G., Analytical instrumentation, Wiley, Chichester, 2000		
Knowledge	Knowledge of the analytical techniques and analytical procedures		
Skills	Explanation of the construction of analytical instrumentation and indications the possibility of its application.		
Other social competences	Correct interpretation of the results		

Course title	PRINCIPLES OF BIOCHEMISTRY		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Agata Markowska-Szczupak	**E-mail address to the person**	Agata.Markowska@zut.edu.pl
Course code (if applicable)	WTiICh-2-56	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	To understand: basic chemical properties of molecules that make life possible, and how these properties relate to specific macromolecular structures and functions. An introduction to biochemical methods to analyze and evaluate the most common compound will be given.		
Entry requirements	Organic Chemistry Principles of Biology		
Course contents	Aminoacids and proteins Enzymes Carbohydrates Lipids DNA isolation. Electrophoresis methods. Protein function, including enzyme catalyzed reactions Structure and function of carbohydrates Lipids and biological membranes Central aspects of metabolism and metabolic control Nucleic acids biochemistry		
Assessment methods	Lecture Laboratory exam (written or oral)		
Recommended readings	1. Murray R.K. et al, Illustrated Biochemistry (Lange Medical Book), McGraw-Hill Medical, 2009., 2009, 29 2. Berg J.M., Tymoczko J.L, Stryer L.,, Biochemistry, W H Freeman, New York, 2002, 5		
Knowledge	Student will understand phenomena, laws, rules, definitions and physical quantities related to biochemistry. Student will know the application of biochemistry. Student will know aspects relating to the plant and animal metabolism.		
Skills	Student will have the ability to biochemical analysis of the different products Student can synthesize news, knows the methodology of research used in biochemistry, knows the development of statistical methods and research results and knows how to interpret it and draw conclusions Student can find information related to the issues of biochemistry		
Other social competences	Student can work with other partners during labs Student can work with other partners during writing reports		

Course title	PRINCIPLES OF ORGANIC CHEMISTRY		
Level of course	second cycle		
Teaching method	lecturing course / laboratory course / lecture		
Person responsible for the course	Jacek Sośnicki	**E-mail address to the person**	Jacek.Sosnicki@zut.edu.pl
Course code (if applicable)	WTiICh-1-57	**ECTS points**	4
Semester	winter	**Language of instruction**	english
Hours per week	5	**Hours per semester**	75
Objectives of the course	The student knows the basic theoretical rules applicable in organic chemistry. The student knows the structures and the basic reactivities of the common functional groups of organic compounds. The student is able to solve the simple problems in organic chemistry. The student uses the basic laboratory techniques. The student knows the basic principles of making an experiment report. The student is aware of the importance of knowledge acquired within the subject for the developement of science and for impovement of the quality of life.		
Entry requirements	Basic knowledge of general chemistry		
Course contents	Exercises in recognizing functional groups, naming organic compounds and writing their structural formulas. Solving simple problems in organic chemistry. The final test. Regulations and safety rules in organic chemistry laboratory. Basic laboratory equipment. Principles of laboratory raport preparation. Determination of melting point and boiling point. Simple and fractional distillations. Preparation and purification of acetanilide, p-bromoacetanilide, aspirin, n-buthyl acetate, dibenzylideneacetone. Organic chemistry in life and science (an introduction). Basic rules of organic chemistry. Overview of the structures and properties of basic functional groups. The functional group transformations – an introduction to the synthesis of organic compounds. The final single choice test.		
Assessment methods	Lecture with discussion. Laboratory exercises. Classes with discussion. Continuous assessment: laboratory reports and activity Writting the final test.		
Recommended readings	1. Andrew F. Parsons, Keynotes in Organic Chemistry, Blackwell Science, 2003 2. John McMurry, Organic Chemistry, Brooks/cole, 2012, 8e 3. John McMurry, Organic Chemistry Solutions Manual, Brook/Cole, 2012, 8e 4. James W. Zubrick, The Organic Chemistry Survival Manual, John Wiley & Sons, 1988, 2 ed		
Knowledge	The student has basic knowledge on the structure and reactivity of functional groups occuring in organic compounds. The student has knowledge of fundamental rules of organic chemistry.		
Skills	The student is able to plan and perform the basic operation in the field of laboratory unit processes.		
Other social competences	The student is aware of the importance of organic chemistry in life and science.		

Course title	PROCESS DYNAMICS		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Maciej Konopacki	**E-mail address to the person**	mkonopacki@zut.edu.pl
Course code (if applicable)	WTiICh-2-58	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The student will be able to: 1. Analyze the transient behavior of chemical engineering processes. 2. Understand the behavior of control systems.		
Entry requirements	Fundamentals of chemical engineering		
Course contents	Formulation of mathematical models of selected chemical engineering systems. Transformation techniques. Linearization of model equations. Process simulation in Matlab Simulink. Detailed analysis of selected processes. Control of selected processes. Introduction. Process modeling fundamentals. Modeling for process operation. Transformation techniques. Linearization of model equations. Frequency response analysis. The dynamic behavior of systems. Detailed analysis of dynamic of selected processes. Process control and instrumentation. Behaviour of controlled processes. Control of selected processes (e.g. mixing process, chemical stirred tank reactors, tubular reactors, heat exchangers, evaporators and separators, distillation columns, fermentation reactors).		
Assessment methods	Lecture illustrated by Power Point presentation and computer simulation Classis illustrated by computer and manual calculations Periodic assessment of student achievement Lecture: exam at the end of the semester Classis: written test		
Recommended readings	1. Roffel B., Betlem B., Process Dynamics and Control. Modeling for Control and Prediction, Wiley, Chichester, 2006 2. Ingham J., Dunn I.J., Heinzle E., Pfenosi1 J.E., Chemical Engineering Dynamics, VCH, Weinheim, 1994 3. Luyben M.L., Luyben W.L., Essentials of Process Control, MCGraw-Hill, New York, 1997		
Knowledge	The student will be able to understand the behavior of control systems.		
Skills	The student will be able to now the behavior of chemical engineering processes and understand the behavior of control systems.		
Other social competences	The student will be able to analyze the transient behavior of chemical engineering processes.		

Course title	PROCESS SAFETY ENGINEERING		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Halina Murasiewicz	**E-mail address to the person**	Halina.Murasiewicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-59	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	Students in this course will learn how to apply basic chemical engineering fundamentals involving energy and mass balances, fluid mechanics, heat and mass transfer, thermodynamics, etc. to the analysis and design of elements of processes and process equipment associated with loss prevention and safe operations involving hazardous materials and/or conditions. Techniques for process hazard analysis, risk assessment, and accident investigations are also covered. A case study approach will allow demonstrating the potential risks involved in many process operations in chemical or similar plants.		
Entry requirements	Fundamentals of mass and energy balances Thermodynamics		
Course contents	Students will analyse a case study in process safety for the selected chemical process or storage of hazardous chemicals by using ALOHA programme and relevant methods applicable to process safety engineering. Process Safety Management; Responsibility; OSHA and EPA Regulations Properties of Toxic Materials; Industrial Hygiene Vaporization Rates; Dilution; Ventilation; Toxic and Flammable Release and Dispersion Modeling Fires and Explosions; Flammability, MOC; Explosions, Detonations, Blast Damage Fire and Explosion Protection and Prevention; Inerting and Purging; Static Electricity; Ventilation Hazard Identification; DOW F&EI, HAZOP, Safety Reviews Risk Assessment; Probability Theory; Event Tree; Fault Tree Accident Investigations- ALOHA programme		
Assessment methods	activating methods: lecture and didactic discussion practical methods - case study/project assessment of progress of the work - monthly written final test/report		
Recommended readings	1. D.A. Crowl, J.A. Louvar, Chemical Process Safety: Fundamentals with Applications, Prentice Hall PTR, 2002 2. R. E. Sanders, Chemical Process Safety, Elsevier, 2011 3. D.P. Nolan, Safety and Security Review for the Process Industries: Application of HAZOP, PHA, What-IF and SVA Reviews, Elsevier, 2014		
Knowledge	Student knows how to apply basic chemical engineering fundamentals involving energy and mass balances, fluid mechanics, heat and mass transfer, thermodynamics, etc. to the analysis and design of elements of processes and process equipment associated with loss prevention and safe operations involving hazardous materials and/or conditions. Techniques for process hazard analysis, risk assessment, and accident investigations are also covered. A case study approach will allow demonstrating the potential risks involved in many process operations in chemical or similar plants.		
Skills	Student will have the following skills in the field of: - calculating the extent of danger zones in natural and turbulent dispersion. - calculation of the extent of hazard zones in the flow scattering. - determination and design of natural ventilation. - determination of explosion hazard zones for industrial and storage facilities.		
Other social competences	Student will be aware of the responsibility for safety in the workplace and in chemical industry and also will know how to eliminate risk of occurrence of potential major industrial accident		

Course title	PROPERTIES AND CHARACTERIZATION OF POLYMERIC MATERIALS		
Level of course	second cycle		
Teaching method	lecture		
Person responsible for the course	Agnieszka Piegat	**E-mail address to the person**	Agnieszka.Piegat@zut.edu.pl
Course code (if applicable)	WTiICh-1-60	**ECTS points**	2
Semester	summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	Students will gain the knowledge about the techniques used for polymers characterization. Students will be able to design research protocol of polymeric materials. Students will be able to use to identify, formulate, and solve problems at the area of polymer characterization.		
Entry requirements	Basic knowledge about polymer synthesis. Nomenclature of polymeric materials		
Course contents	Classification of polymers and their properties. Microscopic techniques in evaluation of polymers morphology (transmission electron microscopy, scanning electron microscopy, light microscopy) Thermal analysis of polymers (DSC, DMTA, TGA) Spectroscopy techniques in polymer science (IR, Raman, UV-Vis) Mechanical properties Molecular weight determination Degradation tests of polymeric materials		
Assessment methods	Lecture - presentation Case study related to polymers characterization Writing exam activating methods: didactic discussion		
Recommended readings	1. Z. Guo, L. Tan, Fundamentals and Applications of Nanomaterials, Artech House, 2009 2. Guo, Qipeng., Polymer morphology : principles, characterization, and processing, John Wiley & Sons., 2016 3. E. Lifshin., Characterization of materials, Weinheim : Wiley-VCH, 2005		
Knowledge	Student will know the application of selected methods in terms of polymer characterisation. Students will know aspects relating to the correct procedure of polymer characterisation, according to selected properties. Student will understand principles of methods used for polymer characterisation.		
Skills	Student will have the ability to polymer analysis based on different techniques Student can find information related to the issue of polymer characterisation Student knows the methodology how to characterized polymeric materials, knows how to interpreted data and draw conclusions		
Other social competences	Student has competences in critical analysis of results quality Students are able to practical use of the knowledge during exam		

Course title	PROPERTIES OF RESERVOIR FLUIDS		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Konrad Witkiewicz	**E-mail address to the person**	Konrad.Witkiewicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-61	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The student will be able to: 1. Demonstrate basic knowledge of reservoir fluids and their properties. 2. Identify the various types of methods in fluid properties estimation. Student will be able to solve typical calculation problems associated with analysis of reservoir fluids.		
Entry requirements	Basic knowledge of mathematics.		
Course contents	Formulation of mathematical models of selected chemical engineering systems. Transformation techniques. Linearization of model equations. Process simulation in Matlab Simulink. Detailed analysis of selected processes. Control of selected processes. Fundamentals of reservoir fluid behavior: classification of reservoir and reservoir fluids, pressure-temperature diagram, oil reservoir, gas reservoir, undefined petroleum fractions. Reservoir-fluid properties: properties of natural gases, behavior of ideal gases, behavior of real gases, effect of non-hydrocarbon components on the Z-factor, non-hydrocarbon adjustment methods, correction for high-molecular-weight gases, gas formation volume factor, properties of crude oil systems, crude oil gravity, specific gravity of the solution gas, gas solubility, bubble-point pressure, oil formation volume factor, crude oil density, crude oil viscosity. Laboratory analysis of reservoir fluids.		
Assessment methods	Lecture Computer laboratory Lecture: written test Classes: written test		
Recommended readings	1. T. Ahmed, Reservoir engineering, Gulf Professional Publishing (Butterworth-Heinemann), Boston, 2001, 2nd ed. 2. B.G. Kyle, Chemical and Process Thermodynamics, Prentice Hall PTR, New Jersey, 1999 3. B.E. Poling, J.M. Prausnitz, J.P. O'Connel, The Properties of Gases and Liquids, McGraw-Hill, New York, 2001		
Knowledge	Student demonstrates knowledge of reservoir fluids and their properties.		
Skills	Student can solve calculation problems associated with analysis of reservoir fluids.		
Other social competences	Student understands the need for continuous training and development in the field of petroleum reservoir engineering.		

Course title	QUALITY ENGINEERING		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Jolanta Szoplik	**E-mail address to the person**	Jolanta.Szoplik@zut.edu.pl
Course code (if applicable)	WTiICh-2-62	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The course aim is to give a general introduction to the theory and practice of quality management and to learn methods useful in quality control and improvement		
Entry requirements	mathematics, statistics - basic course		
Course contents	Calculating average and dispersion for a given detailed data series. Preparing histogram and calculating average, dispersion for interval data series, skewness and flattening of distribution. Calculating the probability of finding (z) scraps in the sample. Application binomial, Poisson and normal distributions for calculating the probability of product meeting the quality requirements Statistical inference in quality control and improvement (sampling from population, check the agreement of distribution feature in sample to normal distribution). Statistical inference for a single and two samples. Designing various Shewhart variables control charts (charts x-R or x-s). Designing various Shewhart attributes control charts (charts p, np, c, u). Designing cumulative sum control chart CUSUM chart for monitoring the mean value for sample and CUSUM chart for number of defects in sample. Designing various single and double-sampling plans for attributes: normal, tightened and reduced types of sampling plans. Designing various sampling plans for variables (normal, tightened and reduced); metods s and sigma. Written test The meaning of quality, quality improvement and quality management. Quality engineering terminology. Statistical methods useful in quality control and improvement. Statistical models for quality control; Important discrete distribution (binomial distribution, Poisson distribution); Important continous distribution (normal dostribution). Statistical process monitoring and control techniques - principles, methods and tools (Pareto chart, cause and effect diagram, scater diagram) Statistical process control: Shewhart control chart (variables or attributes), cumulative sum control chart. Basic acceptance sampling peoblems. Random sampling. Types of sampling plans. Single-sampling plans, double-sampling plans or multiple-sampling plans for attributes. Acceptance sampling plans for variables; method s and sigma. Written test		
Assessment methods	Lecture illustrated by Power Point presentation Examples of solving problems written test		
Recommended readings	1. Doty L.A., Statistical Process Control., Industrial Press Inc., New York, 1996, second edition 2. Montgomery D.C., Statistical Quality Control: A Modern Introduction, John Wiley & Sons, Asia, 2009, sixth edition, International Student Version 3. Montgomery D.C., Introduction to Statistical Quality Control., John Wiley & Sons, 2005, Fifth edition, International Student Version		
Knowledge	Student has the knowledge about the methods and tools used to control the process and product quality.		
Skills	Student has the skill to choose the methods and the calculation of the parameters characterizing the quality of process production and final product.		
Other social competences	Student understands the need to learn constantly of new methods and techniques to solve engineering problems		

Course title	RAW MATERIALS FOR THE COSMETICS PRODUCTS		
Level of course	second cycle		
Teaching method	laboratory course		
Person responsible for the course	Paula Ossowicz	**E-mail address to the person**	Paula.Ossowicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-63	**ECTS points**	2
Semester	winter/summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	Student has knowledge about synthesis and isolations of organic compounds, their identifications by instruments methods		
Entry requirements	organic chemistry inorganic chemistry		
Course contents	Synthesis of cosmetic products Isolation of products from natural sources Identifications and properties of cosmetic compounds		
Assessment methods	laboratory written reports, grade		
Recommended readings	1. Cannell R.J.P., Natural Products Isolation, Humana Press lnc, Totowa, 1998, 4th edition 2. Baki G., Kenneth S.A., Introduction to Cosmetic Formulation and Technology, John Wiley & Sons, Inc, Hoboken, 2015, 1st edition		
Knowledge	Student will have knowledge on the methods of: synthesis of cosmetic products, identifying cosmetic products and determining the biological activity of cosmetic products. Student will have knowledge how to isolate cosmetic products from post-reaction mixtures.		
Skills	Student is able to characterize the obtained products (using the knowledge). Student can determine physicochemical properties (uses knowledge).		
Other social competences	Student can characterize other products of natural origin. Student is able to extract natural raw materials from plant materials.		

Course title	RENEWABLE ENERGY SOURCES		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Halina Murasiewicz	**E-mail address to the person**	Halina.Murasiewicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-64	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	Student is expected to be able to: • List and generally explain the main sources of energy and their primary applications in the world. • Describe the challenges and problems associated with the use of various energy sources, including fossil fuels, about future supply and the environment. • Discuss remedies/potential solutions to the supply and environmental issues associated with fossil fuels and other energy resources. • List and describe the primary renewable energy resources and technologies. • Describe/illustrate basic electrical concepts and system components. • Make quantity/quality comparisons among energy uses, resources, and technologies.		
Entry requirements	Fundamentals of mass and energy balances Thermodynamics Heat transfer		
Course contents	Students will analyse/calculate many examples of the application of renewable energy resources to identify the optimal solutions: PV panel, solar panel, wind tower, heat pumps Introduction to renewable energy sources Energy from the physical view Renewable energy - hydropower, wind energy, solar energy, geothermal energy and energy of biomass Fossil fuels and nuclear energy Transmission and energy storage World energy balance Environmental aspects of energy consumption Economic aspects of energy production and consumption Emerging technologies		
Assessment methods	activating methods: lecture and didactic discussion practical methods - tutorials assessment of progress of the work - monthly written final test/report		
Recommended readings	1. B. Godfrey, Renewable Energy: Power for a Sustainable Future, Oxford Univ. Press, 2004 2. J. F. Manwell, J. G. McGowan, A. L. Rogers, Wind energy explained, theory, design and application, Wiley and sons LTD, 2005 3. Taylor, F. W., Elementary climate physics, Oxford University Press, 2005		
Knowledge	Student is expected to be able to list and generally explain the main sources of energy and their primary applications in the world. Student is expected to be able to describe the challenges and problems associated with the use of various energy sources, including fossil fuels, about future supply and the environment. Student is expected to be able to discuss remedies/potential solutions to the supply and environmental issues associated with fossil fuels and other energy resources. Student is expected to be able to list and describe the primary renewable energy resources and technologies. Student is expected to be able to describe/illustrate basic electrical concepts and system components. Student is expected to be able to make quantity/quality comparisons among energy uses, resources, and technologies.		
Skills	Student can ensure adequate protection of his/her own workplace and assess the risks during testing, measurements and experiments Student is able to acquire, critically evaluate and creatively process information from the scientific literature databases, and other properly chosen sources		
Other social competences	Student is able to define the social role of the graduate of technical university, particularly in the dissemination of technical culture in society and communicating in a meaningful and attractive way information on the achievements of applied energetics and its effects on development of modern technologies, especially in the renewable energy sector Student is able to work as individual or in group		

Course title	RESEARCH PROJECT IN BIOLOGICALLY ACTIVE COMPOUNDS		
Level of course	second cycle		
Teaching method	laboratory course / seminars		
Person responsible for the course	Małgorzata Dzięcioł	**E-mail address to the person**	Malgorzata.Dzieciol@zut.edu.pl
Course code (if applicable)	WTiICh-2-65	**ECTS points**	8
Semester	winter/summer	**Language of instruction**	english
Hours per week	9	**Hours per semester**	135
Objectives of the course	Applying of knowledge and skills learned during studies to solving a practical research problem related to biologically active compounds		
Entry requirements	Fundamentals of chemistry, mathematics and analytical methods		
Course contents	The students accomplish the research project concerning isolation, synthesis or application of biologically active compounds. It consist of literature studies, concept of project realization, selection of used materials, performing the selected process, characteristic of obtained products, control measurements using proper methods and instruments, calculations, discussion of the results, conclusions. Description of all this aspects should be given in the written project report. The students present results of literature studies, concept and progress of project realization.		
Assessment methods	laboratory project seminar assessment of progress of the work presentations during seminar assessment of the quality of written project report		
Recommended readings	1. Literature connected with the research subject, including books, articles and patents		
Knowledge	Student has an extended knowledge about the issues related to the project.		
Skills	Student will be able to analyze new research problems and to propose strategies to solve them. Student will be able to elaborate and to execute research project under the supervision of the tutor. Student will be able to perform evaluation and interpretation of data from the literature and from the experimental work. Student will be able to prepare of written scientific report and to prepare oral presentation using audiovisual ways.		
Other social competences	Student is aware of the responsibility for the results of studies. Student is able to work in an international team.		

Course title	RESEARCH PROJECT IN CARBON SPHERES PRODUCTION		
Level of course	second cycle		
Teaching method	project course / seminars		
Person responsible for the course	Iwona Pełech	**E-mail address to the person**	Iwona.Pelech@zut.edu.pl
Course code (if applicable)	WTiICh-2-66	**ECTS points**	9
Semester	winter/summer	**Language of instruction**	english
Hours per week	9	**Hours per semester**	135
Objectives of the course	Applying of knowledge and skills learned during studies to solving a practical research problem.		
Entry requirements	Fundamentals of chemical engineering Fundamentals of chemistry Fundamentals of analytical chemistry		
Course contents	The students perform the research project concerning production of carbon spheres. It consist of literature studies, concept of project realization, selection of used materials, performing the selected process, characteristic of obtained products, control measurements using proper methods and instruments, calculations, discussion of the results, conclusions. Description of all this aspects should be given in the written project report.The students perform the research project concerning production of carbon spheres. It consist of literature studies, concept of project realization, selection of used materials, performing the selected process, characteristic of obtained products, control measurements using proper methods and instruments, calculations, discussion of the results, conclusions. Description of all this aspects should be given in the written project report. The students present results of literature studies, concept and progress of project realization.		
Assessment methods	discussion demonstrating measurements laboratory seminar activity assessment assessment of progress of the work discussion evaluation of presentation written final project report		
Recommended readings	1. Michio Inagaki, Feiyu Kang, Hidetaka Konno, Advanced Materials Science and Engineering of Carbon Book, Springer, 2014 2. Carlos P. Bergmann, Fernando Machado Machado, Carbon Nanomaterials as Adsorbents for Environmental and Biological Applications, Springer, 2015 3. Sergey P. Gubin, Magnetic Nanoparticles, Viley, 2009 4. C. N. R. Rao, P. J. Thomas, G. U. Kulkarni, Nanocrystals: Synthesis, Properties and Applications, Springer, 2007		
Knowledge	Student knows how to apply chemical engineering fundamentals and instrumental analysis to the preparation and chcaracterization of carbon materials. Student has an extended knowledge about the issues related to the project.		
Skills	Student will be able to obtain information from library, online and literature resources that will support the solving of research problems. Student will be able to plan and carry out experiments, collect experimental data, analyze and interpret results, write technical reports and give presentations.		
Other social competences	Student understands the needs of continuous training and development in the field of nanomaterials. Student knows how to individually study the problem: from it formulate to the solution and also propose possible solutions. Student is able to work in an international team.		

Course title	RESEARCH PROJECT IN CHEMICAL ENGINEERING		
Level of course	second cycle		
Teaching method	project course		
Person responsible for the course	Halina Murasiewicz	**E-mail address to the person**	Halina.Murasiewicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-67	**ECTS points**	8
Semester	winter/summer	**Language of instruction**	english
Hours per week	8	**Hours per semester**	120
Objectives of the course	Learn how to conduct the case study based on literature Learn how to present complex data or situations clearly Learn how to review and analyze research findings that affect the process Learn how to prepare a preliminary research design for projects in their subject matter areas		
Entry requirements	Fundamentals of Chemical Engineering Chemical engineering reaction Physics, mathematics Numerical or process simulation tools: CFD, Aspen Plus, Matlab		
Course contents	Literature review of the subject of a research project Identify an appropriate research design Conduct the appropriate research activities: measurements, numerical simulation, design or calculation Data analysis Write the final research paper according to identified guidelines Meeting with the instructor to discuss research and writing methods and to review progress on his/her research paper		
Assessment methods	activating methods: didactic discussion practical methods - numerical/simulation study assessment of progress of the work - monthly written reports written final project report		
Recommended readings	1. McCabe W.L., Smith J.C., Harriott P., Unit Operations of Chemical Engineering, McGraw-Hill, New York, 2005 2. Sinnott R.K., Coulson & Richardson's Chemical Engineering, Vol. 6: Chemical Engineering Design, Butterworth-Heinemann, Oxford, 2003 3. Moin, P., Fundamentals of Engineering Numerical Analysis, Cambridge University Press, Cambridge, 2010		
Knowledge	Student knows how to apply basic chemical engineering fundamentals involving energy and mass balances, fluid mechanics, heat and mass transfer, thermodynamics, etc. to the analysis and design processes, part of process and process equipment.		
Skills	Student will have the following skills in the field of: - design experiments to obtain relevant data -utilize numerical software packages to simulate transport phenomena and thermodynamics -analyze data appropriately to extract parameters of interest -characterize, quantify, and report error in results and calculations -present technical information effectively in written and verbal form		
Other social competences	Student knows how to individually study the problem: from it formulate to the solution and also propose possible solutions.		

Course title	RESEARCH PROJECT IN GREEN CHEMISTRY		
Level of course	second cycle		
Teaching method	project course		
Person responsible for the course	Beata Kołodziej	**E-mail address to the person**	Beata.Kolodziej@zut.edu.pl
Course code (if applicable)	WTiICh-2-68	**ECTS points**	12
Semester	winter/summer	**Language of instruction**	english
Hours per week	16	**Hours per semester**	240
Objectives of the course	Learn how to conduct the case study based on literature Learn how to present complex data or situations clearly Learn how to review and analyze research findings that affect the process		
Entry requirements	Fundamentals of organic chemistry Fundamentals of structural analysis of organic compounds Fundamentals of green chemistry		
Course contents	synthesis of Schiff bases and their complexes using classical and green methods using methods to establish the structure of obtained compounds: NMR, ATR-FTIR, UV-Vis, XRD, DTA-TG, electrochemical methods. analysis of results based on structural data contac with mentors to discuss research and to review progress on research paper		
Assessment methods	activating methods: didactic discussion practical methods - synthetic and analytical study assessment of progress of the work - monthly written reports written final project report		
Recommended readings	1. John McMurry, Fundamentals of Organic Chemistry, Brooks/Cole Cengage Learning, Belmont, USA, 2011 2. Donald L. Pavia, Gary M. Lampman, George S. Kriz, Introduction to Spectroscopy, Cengage Learning, Stamford, USA, 2015 3. Stanley E. Manahan, Green Chemistry and the Ten Commandments of sustainability, ChemChar Research, Inc., Columbia, Missouri, USA, 2005		
Knowledge	Student knows how to apply basics of organic synthesis and analysis to determine structures of organic compounds, student knows how to analyse and design synthetic process to obtain the pure compound with high efficiency.		
Skills	Student will have the following skills in the field of: - designing experiments to obtain relevant data - utilizing analytical data to determine progress of reaction and to design changes in synthetic methods - characterizing, quantifying, and reporting errors in results - presenting synthetic and analytical information effectively in written and verbal form		
Other social competences	Student knows how to individually study the problem: from it's formulaion to the solution and also propose possible solutions.		

Course title	RESEARCH PROJECT IN POLYMER MATERIALS		
Level of course	second cycle		
Teaching method	project course		
Person responsible for the course	Beata Schmidt	**E-mail address to the person**	Beata.Schmidt@zut.edu.pl
Course code (if applicable)	WTiICh-2-69	**ECTS points**	8
Semester	winter/summer	**Language of instruction**	english
Hours per week	6	**Hours per semester**	90
Objectives of the course	Learn how to conduct the case study based on literature Learn how to present complex data or situations clearly Learn how to review and analyze research findings that affect the process Learn how to prepare a preliminary research design for projects in their subject matter areas		
Entry requirements	Fundamentals of Chemical Engineering Chemical engineering reaction Physics, mathematics		
Course contents	Literature review of the subject of a research project Conduct the appropriate research activities: measurements, experiments, design or calculation Data analysis Write the final research raport according to identified guidelines Meeting with the instructor to discuss research and writing methods and to review progress on his/her research raport		
Assessment methods	activating methods: didactic discussion practical methods - laboratory work, data analysis assessment of progress of the work - monthly written reports written final project report		
Recommended readings	1. McCabe W.L., Smith J.C., Harriott P., Unit Operations of Chemical Engineering, McGraw-Hill, New York, 2005 2. Sinnott R.K., Coulson & Richardson's Chemical Engineering, Vol. 6: Chemical Engineering Design, Butterworth-Heinemann, Oxford, 2003 3. Moin, P., Fundamentals of Engineering Numerical Analysis, Cambridge University Press, Cambridge, 2010		
Knowledge	Student knows how to apply basic polymer chemical engineering involving polymeryzation, mass balances, analysis of polymer materials and design processes.		
Skills	Student will have the following skills in the field of: - design experiments to obtain relevant data -analyze data appropriately to extract parameters of interest -characterize, quantify, and report error in results and calculations -present technical information effectively in written and verbal form		
Other social competences	Student knows how to individually solve the problems in polymer chemistry.		

Course title	RESEARCH PROJECT ON MIXING OF MULTIPHASE SYSTEMS		
Level of course	second cycle		
Teaching method	laboratory course / project course		
Person responsible for the course	Anna Kiełbus-Rąpała	**E-mail address to the person**	Anna.Kielbus-Rapala@zut.edu.pl
Course code (if applicable)	WTiICh-2-70	**ECTS points**	15
Semester	winter/summer	**Language of instruction**	english
Hours per week	20	**Hours per semester**	300
Objectives of the course	The research project aims to give the material needed to prepare diploma work		
Entry requirements	course: Agitation and Agitated Vessels course: Chemical Engineering Fundamentals		
Course contents	Experimental study of hydrodynamics in mechanically agitated multiphase systems Computations of the measurements results Literature survey on mechanically agitated multiphase systems Analysis of the experimental results obtained in laboratory work Preparation of the final research report		
Assessment methods	Laboratory work Projects method final research project		
Recommended readings	1. Harnby N., Edwards M.F., Nienow A.W., Mixing in the Process Industries, Butterworth-Heinemann, Oxford, 1997 2. Mixing Equipment (Impeller Type), AiChE Equipment Testing Procedure, 3rd Edition, New York, 2001, ISBN 0-8169-0836-2 3. Nagata S., Mixing. Principles and Applications, Halsted Press, New York, 1975 4. Paul E.L., Atiemo-Obeng V.A., Kresta S.M (Ed.), Handbook of Industrial Mixing, John Wiley & Sons, Inc., New York, 2004 5. Tatterson G.B., Fluid Mixing and Gas Dispersion in Agitated Tanks, McGraw-Hill, New York, 1991		
Knowledge	to give the material needed to prepare diploma work on mixing of multiphase systems		
Skills	to provide practical knowledge within the framework of the mixing of multiphase systems		
Other social competences	student understands the needs of continuous training and development in the field of the mixing of multiphase systems		

Course title	RESEARCH PROJECT ON POLYMERIC BIOMATERIALS		
Level of course	second cycle		
Teaching method	project course / lecture		
Person responsible for the course	Agnieszka Piegat	**E-mail address to the person**	Agnieszka.Piegat@zut.edu.pl
Course code (if applicable)	WTiICh-2-71	**ECTS points**	4
Semester	summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	Learn how to conduct the case study based on literature Learn how to review and analyze research findings that affect the process Learn how to prepare a preliminary research design for projects in their subject matter areas Learn about economical and leagal aspects related to biomaterials technologies		
Entry requirements	Fundamentals of polymer synthesis and processing Fundamentals of polymeric biomaterials		
Course contents	Literature review of the subject of a research project Identify an appropriate research design Write the final research paper according to identified guidelines Meeting with the instructor to discuss research and writing methods and to review progress on research paper Introduction to the research project assumptions Biomaterials: European Regulatory and Legal Aspects — a Synthetic Approach Case studies - exaplmes of innovative technologies, spin-off companies in the field of biomaterials		
Assessment methods	lecture activating methods: didactic discussion assessment of the work progress - monthly reports writing test writing final project report		
Recommended readings	1. ISO 10993: Biological evaluation of medical devices, parts 1-20 2. Pellicer, Eva. - Redaktor, Advances in applications of industrial biomaterials, Springer International Publishing AG, 2017 3. Padinjakkara, Aneesa, Biopolymer and biomaterials, Oakville ; Waretown : Apple Academic Press,, 2019		
Knowledge	Student knows how to apply basic polymer technology fundamentals involving materials processing, thermal properties analysis, sterilization process etc. to the design of new products, technology line or bioproducts		
Skills	Student will have the following skills in the field of: - design technological process to obtain relevant product -analyze data appropriately to extract parameters of interest -characterize, quantify, and report economical calculations -present technical information effectively in written and verbal form		
Other social competences	Student knows how to individually study the problem: from it formulate to the solution and also propose possible solutions.		

Course title	SELECTED ISSUES IN POLYMER CHEMISTRY		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Beata Schmidt	**E-mail address to the person**	Beata.Schmidt@zut.edu.pl
Course code (if applicable)	WTiICh-2-72	**ECTS points**	2
Semester	winter/summer	**Language of instruction**	english
Hours per week	2	**Hours per semester**	30
Objectives of the course	The student will be able to demonstrate basic knowledge of polymer chemistry.		
Entry requirements	Basic knowledge of chemistry.		
Course contents	1.Copolymerization Polymer sorption studies Polymer flocculation studies Polymers; Molar mass of polymers and distribution of molar mass; Mechanism of polymerisation; Radical polymerisation; Anionic polymerisation, Cationic polymerisation; Methods of polymerisation; Copolymerisation;		
Assessment methods	Lecture and laboratory Lecture: discusion		
Recommended readings	1. Akihiro Abe [et al.]., Biopolymers, PVA Hydrologes, Anionic Polymerisation, Nanocomposites, 2005 2. M. Biswas [et al.]., New polymerization techniques and synthetic methodologies		
Knowledge	Student demonstrates knowledge of polymer chemistry.		
Skills	Student can do polymeryzation and solve calculation problems associated with analysis of polymer materials.		
Other social competences	Student understands the need for continuous training and development in the polymer chemistry.		

Course title	SELF-HEALING MATERIALS FOR AIR PURIFICATION		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Ewelina Kusiak-Nejman	**E-mail address to the person**	Ewelina.Kusiak@zut.edu.pl
Course code (if applicable)	WTiICh-2-73	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The course is aimed at giving an overview of self-cleaning and related processes for environmental application. Student will be able to define basic processes, including self-cleaning mechanisms, materials with self-cleaning properties, etc. Student will be able to know the mechanisms of decomposition of inorganic and organic pollutants from self-healing surfaces. Student will be able to know the application of self-healing products in real life.		
Entry requirements	The basic knowledge of basic safety rules. Basic knowledge of air contamination with organic and inorganic compounds.		
Course contents	Preparation, chracterization and activity of photocatalytic concretes Preparation, physicochemical characterization and self-cleaning properties of photocatalytic gypsum-based building materials Photocatalytic oxidation of NO with the presence of carbon fibers modified with titanium dioxide Photocatalytic oxidation of volatile organic compounds in the presence of carbon fiber cloths modified with titanium dioxide Inactivation of bioaerozols present in air utilizing photocatalytic building materials Fundamentals of self-cleaning processes Modern self-cleaning materials: concteres, brikcs, paints, monoliths, etc. Preparation methods of self-healing surfaces Characterization methods of self-cleaning materials Degradation of inorganic compounds from air with the application of self-cleaning surfaces Degradation of organic compounds from air with the application of self-cleaning surfaces Inactivation of microbials with self-cleaning products: mechanisms and application		
Assessment methods	Lectures Discussion with the teacher Final written test - lectures Preparation of laboratory reports - laboratory classes A test to check preparation for laboratory activities - laboratory classes		
Recommended readings	1. Siavash Hosseinpour Chermahini, Kaveh Ostad-Ali-Askari, Saeid Eslamian, Vijay P. Singh, Recent Progress in Self-Cleaning Materials with Different Suitable Applications, American Journal of Engineering and Applied Sciences, 2018, 11 (2), OI: 10.3844/ajeassp.2018.560.573 2. Walid D. Daoud (Ed.), Self-cleaning Materials and Surfaces, John Wiley & Sons Ltd., Chichester, UK, 2013, ISBN: 978-1-119-99177-9 3. Prathapan Ragesh, V. Anand Ganesh, Shantikumar V. Nair, A. Sreekumaran Nair, A review on 'self-cleaning and multifunctional materials', Journal of Materials Chemistry A, 2014, 4, DOI: 10.1039/C4TA02542C 4. Walid A. Daoud (Editor), Self-Cleaning Materials and Surfaces: A Nanotechnology Approach, Wiley, 2013, ISBN-13: 978-1119991779		
Knowledge	As a result, the student should be able to define basic concepts related to self-healing air purification. As a result of the classes, the student should be able to explain the mechanisms of self-cleaning processes. As a result, the student should be able to know the routes of application of the self-cleaning materials for environmental application.		
Skills	As a result of the classes, the student should know how to interpret the results of photocatalytic degradation processes of pollutants from water and air utilizing modern self-cleaning materials. As a result of the classes, the student should know how to prepare laboratory reports containing results and conclusions.		
Other social competences	As a result of the conducted classes, the student will acquire the following attitudes: caring for the environment, openness to changes related to the water contamination, acting in accordance with the rules of ethics, awareness the results of water contamination as a global aspect.		

Course title	SEPARATION PROCESSES		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Bogdan Ambrożek	**E-mail address to the person**	Bogdan.Ambrozek@zut.edu.pl
Course code (if applicable)	WTiICh-2-74	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The student will be able to: 1. Demonstrate basic knowledge of separation of chemical mixtures by industrial processes, including bioprocesses. 2. Describe the scientific principles associated with separation equipments. 3. Demonstrate basic knowledge of making mass balances and specifying component recovery and product purity. 4. Demonstrate basic knowledge of modeling and simulation of separation processes using POLYMATH, ASPEN PLUS and HYSYS.		
Entry requirements	Fundamentals of chemical engineering		
Course contents	Thermodynamic analysis of selected separation processes. Single equilibrium stages calculations. Flash calculations. Calculation of selected separation processes: distillation, liquid–liquid extraction, supercritical extraction, membrane separations, adsorption, ion exchange, chromatography, electrophoresis, mechanical phase separations. Modeling and simulation of separation processes using POLYMATH, ASPEN PLUS and HYSYS. Introduction. Fundamental concepts. Thermodynamics of separation processes. Mass transfer and diffusion. Flash calculations. Absorption. Stripping of dilute mixtures. Distillation. Liquid–liquid Extraction. Membrane separations. Adsorption. Ion exchange. Chromatography. Modeling and simulation of separation processes using POLYMATH, ASPEN PLUS and HYSYS.		
Assessment methods	Lecture illustrated by Power Point presentation and computer simulation Classis illustrated by computer and manual calculations Periodic assessment of student achievement Lecture: exam at the end of the semester Classis: written test		
Recommended readings	1. Seader J.D., Henley E.J., Separation process principles, Wiley, New York, 2006 2. Seader J. D., Henley E.J., Roper D.K., Martin R.E., Separation process principles. Chemical and biochemical operations, Wiley, New York, 2011 3. Wankat P.C., Separation Process Engineering, Prentice Hall, New Jersey, 2012 4. Noble R.D., Terry P.A., Principles of chemical separations with environmental applications, Cambridge University Press, New York, 2004		
Knowledge	The student will be able to demonstrate basic knowledge of separation of chemical mixtures by industrial processes, including bioprocesses.		
Skills	The student will be able to describe the scientific principles associated with separation equipments.		
Other social competences	The student will be able to demonstrate basic knowledge of modeling and simulation of separation processes using POLYMATH, ASPEN PLUS and HYSYS.		

Course title	SPECIAL METHODS OF SEPARATION		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Anna Kiełbus-Rąpała	**E-mail address to the person**	Anna.Kielbus-Rapala@zut.edu.pl
Course code (if applicable)	WTiICh-2-75	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The course aim is to give information about special techniques used to separation of substances: the principle of separation, physical basis, equipment, advantages and disadvantages of particlular method; the examples of use. Shaping the skills of calculations in the field of special separation methods and apparatus used in these methods		
Entry requirements	Basis of Chemical Engineering		
Course contents	Calculation of tasks related to processes and apparatus in the field of special separation methods discussed during the lecture written exam Introduction to the subject. Division and general characteristics of special separation methods. Permeation. Mechanisms for transporting the component through the membrane. Classification of permeation separation methods. Division of methods due to the driving force of the process. Characteristics of permeation methods: membrane separation processes: micro-, ultra- and nanofiltration, reverse osmosis, electrolysis, dialysis, electrodialysis, gas and vapour permeation, pervaporation, membrane distillation. Liquid membranes. Basis of processes. Examples of use. Membrane separation in nuclear technology. Isotope separation. Purification of liquid radioactive waste by ultrafiltration. Concentration of radioactive solutions by membrane distillation. Separation in ultracentrifuges. Theoretical basis of the process. Centrifuge construction. Thermal diffusion method. Apparatus used to separate components of mixtures by thermodiffusion method. Construction solutions of thermal diffusion columns for separation of liquid mixtures and gas mixtures Surface sorption methods; bubble or foam separation, flotation. Foam flotation. Crystallization methods. Zone refining (zone melting). Additive crystallization. Coprecipitation. Electroforetic separation methods. Electroforetic carriers. Division of electroforetic methods. Capillary electrophoresis. Types of electrophoresis. Application of electromigration techniques. Chromatografic separation method. Chemical methods. Ion exchange. Ionites classification. Separation methods using a magnetic field written test		
Assessment methods	Lecture illustrated by presentation Exercises writen test		
Recommended readings	1. Bitter J.G.A, Transport Mechanisms in Membrane Separation Processes, 1991 2. Patnaik, P., Dean's Analytical Chemistry Handbook, McGraw-Hill, 2004, 2nd Edition 3. Henley, E.J., Seader, J.D., Roper D.K., Separation Process Principles, Wiley, 2013, 3rd Edition 4. Reiner Westermeier, Electrophoresis in practice, Wiley, 2005, 3rd Edition 5. Rickwood D., Ford T., Steensgaard J., Centrifugation: Essential Data, John Wiley & Sons, Inc., 1994		
Knowledge	Student has the knowledge about the different special methods used to separation of mixtures. The student has the skills to explain physical basis, principles of operation of a particular method and the equipment required for it		
Skills	Student has the skills to choose the appropriate method of separation for a given mixture and to explain away the choice Student has the skills to calculate basic parameters and solve different problems in the field of special methods of separation and apparatus used in these methods		
Other social competences	The student understands the need to learn constantly of new methods and techniques to solve engineering problems		

Course title	SPECTROSCOPIC METHODS		
Level of course	second cycle		
Teaching method	lecturing course / laboratory course / lecture		
Person responsible for the course	Elwira Wróblewska	**E-mail address to the person**	Elwira.Wroblewska@zut.edu.pl
Course code (if applicable)	WTiICh-2-76	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	5	**Hours per semester**	75
Objectives of the course	To gain the knowledge about the theory of spectroscopic methods and their application in qualitative and quantitative analysis.		
Entry requirements	Fundamentals of physical chemistry. Fundamentals of organic chemistry.		
Course contents	Calculation of a compound concentration expressed in various concentration units. Calculation the concentration of a solution after dillution. Solving some excercisses concerning the interaction of the matter with light (absorbance, transmitance). Determination of compounds based on Lambert-Beer's low in single and multicomponent mixtures. The application of calibration curve in quantitative analysis of componds. Limit of detection, method sensitivity and precision - calculation. The application of NMR spectroscopy in qualitative and quantitative analysis of organic compounds (the calculation of the position of the band corresponding to particular proton on the basis on empirical equations, determination of a compound purity). Application of MS spectra in determination of organic compounds composition (Beynon table). The measurements of UV-vis spectra and their application in qualitative and quantitative analysis of various compounds. The recording and interpretation of IR spectra. Analysis of multicomponent mixtures by spectroscopic methods supported by computer programs. Precise analysis of NMR spectra with the use of technical software. The interpretation of MS spectra of various group of organic compounds. Explanation of wave-particle duality of electromagnetic radiation and influence of its absorption/emission by atom or molecule on their properties. Theoretical studies of phenomena proceeding in the molecule/atom under the irradiation. The theory of ultraviolet-visual spectroscopy (UV-VIS); the Lambert-Beer's low and the reason of the departure from this low: association, solvatochromism, thermochromism, photochromism, halochromism. The application of UV-vis spectrophotometry to the analysis of multicomponent mixtures (theory, mathematics and software). The use of UV-vis spectrophotometers into the studies of luminescent materials. Infrared spectroscopy (IR) and its application to qualitative analysis of solids and liquids. The application of IR spectroscopy to quantitative analysis of compounds (methods, their possibilities and limitations). The theory of NMR spectrometry. The analysis of the spectra of various compounds. MS spectrometry: types of MS spectrometers, the methods of ionisation.		
Assessment methods	The lectures with the discussion. Classes Laboratory Written exam and/or oral discussion Assessment of laboratory written report Assessment of homework assignments. Evaluation of the student’s work based on the student activity during the course.		
Recommended readings	1. Field, L. D, Strnhell, S, Kalman, J.R., Organic structures from spectra, Chichester: John Wiley and Sons, 2002 2. Bartecki, A. , Lang, L., Absorption spectra in the ultraviolet and visible region., House of the Hungarian. Academy of Sciences, Budapest, 1982 3. Láng, L., Holly, S, Sohár, P., Absorption spectra in the infrared region, Akadémiai Kiadó, Budapest, 1980 4. Rahman, Atta-ur, One and two dimensional NMR spectroscopy,, Elsevier, Amsterdam, 2011 5. Perkampus, Heinz-Helmut, Encyclopedia of spectroscopy, Weinheim : VCH, 1995		
Knowledge	He has a knowledge about the fundamentals of the selected spectroscopic method and their application in qualitative and quantitative analysis.		
Skills			

	Student is able to make some calculation concerning the analysis with the interpretation of obtained results. Student can plane and carry the experiment with the interpretation of obtained results.
Other social competences	Student is able to choose the appropriate method in order to solve particular problem.

Course title	STATISTICAL METHODS IN ENGINEERING		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Anna Story	**E-mail address to the person**	Anna.Story@zut.edu.pl
Course code (if applicable)	WTiICh-2-77	**ECTS points**	3
Semester	summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	The course aims to give a general introduction to the theory and practice of statistical methods in engineering		
Entry requirements	Applied Mathematics		
Course contents	Calculations of exercises connected with application of statistical techniques which are included to lectures content. Practical using of software (Excel, MATLAB) for statistical analysis. Introduction to statistics and data visualisation. Theoretical foundation for statistical analysis. Regression. Design of experiments. Modelling stochastic processes with time Ssries aalysis. Modelling dynamic processes using system identification methods. Using Excel to do statistical analysis. Using MATLAB for statisitical analysis. Written test.		
Assessment methods	Activating methods: lecture illustrated by multimedia presentation and didactic discussion Practical methods: execution of exercises Lectures and classes - written final test Written report after computer exercises		
Recommended readings	1. Yuri A.W. Shardt, Statistics for chemical and process engineers : a modern approach, Springer, 2015, ISBN: 9783319215082		
Knowledge	Students will acquire detailed theoretical knowledge on many aspects within the framework of the statistical methods in engineering		
Skills	Students will acquire practical knowledge on many aspects within the framework of the statistical methods in engineering		
Other social competences	Students have the ability to solving and analyzing processes with using the statistical methods in engineering. Students understand the needs of continuous training and development in the field of statistical methods		

Course title	SURFACTANTS CHEMISTRY AND ANALYSIS		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Paula Ossowicz	**E-mail address to the person**	Paula.Ossowicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-78	**ECTS points**	3
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	45
Objectives of the course	Student has knowledge about physical properties of surfactants and their solutions (solubility, Kraft point, cloud point, adsorption at interfacial surface, interfacial tension) Student has knowledge about colloids with surfactants - micelles, emulsions and microemulsions, liquid crystals Student has knowledge about effects delivered by surfactants - including wetting, foaming, detergency, emulsification, solubilisation Student has skills of determination of surfactants and their properties in different commercial products		
Entry requirements	organic chemistry inorganic chemistry		
Course contents	Determination of cloud points of nonionic surfactants. Effect of chemical structure on the cloud point. Determination of the surface tension of surfactant solutions-effect of surfactants structure and additives. Critical micelle concentration - methods of determination Determination of Krafft point and solubility of surfactants Analysis of anionic and cationic surfactants in different commercial products Chemical and thermal stability of surfactants Characteristics and Classification of Surfactants The Use of Surfactants to Enhance Particle Removal from Surfaces Adsorption of surfactants at interfaces - surface tension, surface excess; interfacial tension, contact angle, wetting of surfaces, and methods of measurements Surfactant solubility; self-assembled surfactants aggregates - micelles and critical micelle concentration, factors affecting the CMC, the structure of micelle and molecular packing; liquid crystalline mesophases; Detergency: Theory and Test Methods Emulsions and Emulsion Technology Applications of surfactants Surfactant Biodegradation		
Assessment methods	Laboratory Lectures project work continuous assessment final written test - lectures		
Recommended readings	1. R. J. Farn (Ed.), Chemistry and Technology of Surfactants, Blackwell Publishing, 2006 2. M. R. Potter, Handbook of surfactants, Springer Science + Business Media, 1993, Chapter 4 3. European standards		
Knowledge	Student will have knowledge of surfactant properties, their interaction with substrates and analysis methods		
Skills	Uses knowledge to characterize the basic physicochemical properties of surfactants and their solutions as well as colloidal systems created with their participation.		
Other social competences	Student is able to indicate by-products and waste substances arising in the production process of selected groups of surfactants and their impact on the quality of surfactants and the ways of their elimination.		

Course title	TECHNICAL AND INDUSTRIAL ANALYSIS		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Ewa Ekiert	**E-mail address to the person**	Ewa.Dabrowa@zut.edu.pl
Course code (if applicable)	WTiICh-2-79	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	3	**Hours per semester**	50
Objectives of the course	Student knows the principles of organization and functioning as well as management of a modern industrial laboratory and the basics of Quality Management Systems. Student knows major research/testing techniques and methodologies of the basic parameters of raw materials, semi-products and products		
Entry requirements	Analytical chemistry		
Course contents	Sampling methods for solid, liquid and gas samples Determination of major physicochemical and technical properties for selected materials / process streams Characterization methods of technical products Preparation of the sample for testing the content of elements and ions by instrumental methods A visit to an industrial technical laboratory Modern Industrial Laboratory Quality management systems in the laboratory according to ISO/IEC 17025, ISO 9001 and Good Laboratory Practice Techniques and methods of sampling and preparation of samples for research / analysis Major techniques and methodologies for testing the basic parameters of raw materials, semi-products and products Methods for determining elemental, chemical and phase composition The use of electrochemistry in Technical and Industrial Analytics Evaluation and quality control of analytical measurement results		
Assessment methods	Lecture Laboratory Passing laboratory classes based on attendance and reports. Lecture - exam.		
Recommended readings	1. H. Gunzler, Accreditation and Quality Assurance in Analytical Chemistry, Springer, Heidelberg, 1996		
Knowledge	Student knows basics in the scope of quality control of products, raw materials, semi-finished products, process streams; optimal rules for the organization of laboratory work; rules for the selection and supervision of equipment and consumables. Student understands the essence of the analytical procedure, has knowledge of the parameters of leading instrumental analytical techniques and criteria for the selection of techniques depending on the purpose of the analysis.		
Skills	Student is able to choose: the method of preparation of the analytical sample depending on the analytical technique used; the analytical technique depending on the purpose of analysis. Student is able to perform basic determinations using basic and representative analyzers for a given technique		
Other social competences	Student is able to make an initial assessment and decide on the choice of analytical technique depending on the purpose of the analytics and is able to perform basic analytical consultations with analysts dealing with a specific analytical technique, is able to work in a team implementing complete analytical procedures		

Course title	TECHNICAL THERMODYNAMICS		
Level of course	second cycle		
Teaching method	lecturing course / laboratory course / lecture		
Person responsible for the course	Konrad Witkiewicz	**E-mail address to the person**	Konrad.Witkiewicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-80	**ECTS points**	6
Semester	winter	**Language of instruction**	english
Hours per week	6	**Hours per semester**	90
Objectives of the course	The student will be able to demonstrate basic knowledge of technical thermodynamics. Student will be able to solve theoretical problems associated with technical thermodynamics. Student will be able to solve practical problems associated with technical thermodynamics.		
Entry requirements	Basic knowledge of mathematics.		
Course contents	Solving problems presented during lectures. Solving selected practical problems in technical thermodynamics: Heat transfer and conduction studies; Determination of enthalpy of salt and hydroxide dissolution process; Determination of entropy change of a solid body; Measurement of gas flow parameters; Determination of specific heat of solid and liquid; Determination of the melting heat of ice; Air humidity test, Cp/Cv determination. Basic thermodynamic concepts. The properties and laws of ideal and semi-ideal gases. The first law of thermodynamics: heat, specific heat. Absolute work, useful work, technical work. The first law of thermodynamics for open and closed systems. Open-system energy balances on process equipment: nozzles and diffusers, turbines and pumps/compressors, heat exchangers, throttling devices. The transformations of ideal and semi-ideal gases: isobaric, isochoric, isothermal, isentropic and polytropic. Thermodynamic cycles. Carnot cycle. Rankine cycle. Refrigeration cycles. Liquefaction cycles. Combustion engines. The second law of thermodynamics: entropy, reversible and irreversible processes. Water vapor, phase changes of water, steam diagrams.		
Assessment methods	Lecture Classes Laboratory Lecture: written exam Classes: written test Laboratory: reports		
Recommended readings	1. C. Borgnakke, R.E. Sonntag, Fundamentals of thermodynamics, Wiley, New York, 2013, 8th 2. H.D.B. Jenkins, Chemical Thermodynamics at Glance, Blackwell Publishing Ltd, Oxford, 2008		
Knowledge	Student demonstrates knowledge of chemical and process thermodynamics		
Skills	Student can solve problems associated with thermodynamic systems.		
Other social competences	Student understands the need for continuous training and development in the field of chemical and process thermodynamics.		

Course title	TECHNOLOGIES IN ENVIRONMENTAL PROTECTION		
Level of course	second cycle		
Teaching method	lecturing course / laboratory course / lecture		
Person responsible for the course	Małgorzata Dzięcioł	**E-mail address to the person**	Malgorzata.Dzieciol@zut.edu.pl
Course code (if applicable)	WTiICh-2-81	**ECTS points**	5
Semester		**Language of instruction**	english
Hours per week	5	**Hours per semester**	75
Objectives of the course	Knowledge about air, water and soil pollutants. Knowledge about the technologies and processes used in removal of environmental contaminants.		
Entry requirements	Basics of inorganic and organic chemistry		
Course contents	Environmental pollutants - sources, toxicity, effects, methods of emission control. Removal of sulfur and nitrogen oxides from combustion gases. Methods of clean-up of municipal and industrial effluents. Elimination of iron from water The use of activated carbon for removal of oxidazable compounds from water Elimination of phosphorus from water by precipitation method Determination of nitrogen dioxide in air by spectrophotometric method Adsorption of toluene on granular activated carbon Study of paracetamol adsorption Basic concepts and strategies in environmental protection. Sources of air pollutants emission. Global problems of air protection. Systems of monitoring of air pollutants. Methods of particulate matter emission control. Types of dust collectors (settling chambers, inertial dust collectors, cyclones, wet scrubbers, fabric filters, electrostatic precipitators). Methods of gas emission control (absorption, adsorption, thermal and catalytic combustion, condensation, biofiltration). Sources of water contaminants. Characteristic, classification and composition of effluents. Technologies for removal of contaminants from water (conventional treatment systems: primary and secondary treatment, advanced treatment processes). Soil pollution. Solid wastes management. Written test (grade).		
Assessment methods	Lecture with presentation Discussion Seminar Laboratory Individual work with the literature Evaluation of presentation Evaluation of written reports Evaluation of work in the laboratory Written test (grade)		
Recommended readings	1. S. E. Manahan, Environmental science and technology, CRC Taylor & Francis, Boca Raton, London, New York, 2007 2. R.M. Harrison (ed.), Pollution - Causes, Effects and Control, Royal Society of Chemistry, 2014, 5th edition 3. D. Vallero, Fundamentals of Air Pollution, Elsevier, 2014, 5th edition 4. K. Meyer, Handbook of Environmental Engineering, John Wiley & Sons, 2018 5. C. Binnie, M. Kimber, H. Thomas, Basic Water Treatment, ICE Publishing, London, 2018, 6th edition 6. A. T. Gireczycki, Ł. Kurowski, J. Thullie, Gas cleaning and wastewater treatment for industrial and engineering chemistry students, Politechnika Śląska, Gliwice, 2011		
Knowledge	Student will be able to characterize popular environmental pollutants and indicate sources of emission. Student will be able to explain principles of operation of devices and technologies used in environment protection.		
Skills	Student will be able to collect, organize and present data from literature. Student will be able to practically perform selected processes of environmental pollutants removal and analysis.		
Other social competences	Student is aware of the harmful effects connected with environmental pollution.		

Course title	TESTING METHODS OF INORGANIC PRODUCTS		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Dariusz Moszyński	**E-mail address to the person**	Dariusz.Moszynski@zut.edu.pl
Course code (if applicable)	WTiICh-2-82	**ECTS points**	5
Semester	winter/summer	**Language of instruction**	english
Hours per week	6	**Hours per semester**	90
Objectives of the course	Student knows the most important analytical methods utilized for testing inorganic samples Student is able to chose a proper group of analytical methods to assess given set of properties Student knows how to prepare samples for analytical methods and is able to carry out simple analysis		
Entry requirements	Inorganic chemistry Physics		
Course contents	Selecting of a proper analytical methods Instrumental methods of chemical composition analysis X-ray Photoelectron Spectroscopy and Auger Electron Spectroscopy Thermogravimetry Temperature Programmed Desorption X-Ray Diffraction Scanning Electron Microscopy Instrumental methods of chemical composition analysis Chemical analysis of the surface of solid state Adsorption/desorption methods and temperature programmed techniques Analysis of phase composition, structure and topography		
Assessment methods	Lecture Laboratory Exam		
Recommended readings	1. John A. Dean, Analytical Chemistry Handbook, McGraw-Hill Companies, 2000		
Knowledge	Student knows the most important analytical methods utilized for testing inorganic samples		
Skills	Student is able to chose a proper group of analytical methods to assess given set of properties		
Other social competences	Student is competent in analysis of inorganic materials		

Course title	THERMODYNAMICS OF PHASE AND REACTION EQUILIBRIA		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Konrad Witkiewicz	**E-mail address to the person**	Konrad.Witkiewicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-83	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The student will be able to demonstrate basic knowledge of thermodynamics of phase and reaction equilibria. Student will be able to solve engineering problems associated with thermodynamics of phase and reaction equilibria.		
Entry requirements	Basic knowledge of mathematics.		
Course contents	Solving problems presented during lectures. The Criteria for Equilibrium, Molecular View of Equilibrium, Gibbs Phase Rule, Pure Species Phase Equilibrium, Gibbs Energy, Clausius–Clapeyron Equation, Partial Molar Properties, The Gibbs–Duhem Equation, Property Changes of Mixing, The Chemical Potential, Fugacity and Fugacity Coefficient, The Lewis Fugacity Rule, Fugacity in the Liquid Phase, Fugacity in the Solid Phase, Vapor–Liquid Equilibrium (VLE) , Raoult's Law, Nonideal Liquids, Azeotropes, Solubility of Gases in Liquids, Liquid—Liquid Equilibrium, Vapor–Liquid—Liquid Equilibrium, Solid–Liquid and Solid–Solid Equilibrium, Chemical Reaction Equilibria, Chemical Reaction and Gibbs Energy, The Equilibrium Constant for Reaction, Electrochemical Reaction Equilibrium, Activity Coefficients in Electrochemical Systems, Multiple Reactions, Extent of Reaction.		
Assessment methods	Lecture Classes Lecture: written exam Classes: written test		
Recommended readings	1. M.D. Koretsky, Engineering and chemical thermodynamics, Wiley, New York, 2013, 2nd 2. H.D.B. Jenkins, Chemical Thermodynamics at Glance, Blackwell Publishing Ltd, Oxford, 2008 3. J.M. Prausnitz, R.N. Lichtenthaler, E.G. de Azevedo, Molecular Thermodynamics of Fluid Phase Equilibria, Prentice Hall PTR, New Jersey, 2001		
Knowledge	Student demonstrates basic knowledge of scientific principles associated with solving thermodynamic problems.		
Skills	Student can solve engineering problems associated with thermodynamic equilibria.		
Other social competences	Student understands the need for continuous training and development in the field of chemical thermodynamics.		

Course title	THERMODYNAMICS WITH CHEMICAL ENGINEERING APPLICATIONS		
Level of course	second cycle		
Teaching method	laboratory course / lecture		
Person responsible for the course	Konrad Witkiewicz	**E-mail address to the person**	Konrad.Witkiewicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-84	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The student will be able to demonstrate basic knowledge of thermodynamics associated with chemical engineering applications. Student will be able to solve typical calculation problems associated with thermodynamics.		
Entry requirements	Basic knowledge of mathematics.		
Course contents	Solving problems presented during lectures. Thermodynamic Properties, The PvT Surface, Thermodynamic Property Tables, The First Law of Thermodynamics, Internal Energy of an Ideal Gas, Work and Heat, Construction of Hypothetical Paths, Reversible and Irreversible Processes, The First Law of Thermodynamics for Closed Systems, The First Law of Thermodynamics for Open Systems, Material Balance, Flow Work, Enthalpy, Steady-State Energy Balances, Transient Energy Balance, Heat Capacity, Latent Heats, Enthalpy of Reactions, Reversible Processes in Closed Systems, Heat Capacity, Open-System Energy Balances on Process Equipment: Nozzles and Diffusers; Turbines and Pumps (or Compressors); Heat Exchangers; Throttling Devices; Entropy, The Second Law of Thermodynamics for Closed and Open Systems, The Mechanical Energy Balance and the Bernoulli Equation, Thermodynamic Cycles, Vapor-Compression Power and Refrigeration Cycles, The Rankine Cycle, The Vapor-Compression Refrigeration Cycle, Exergy Analysis, The Ideal Gas, Intermolecular Forces, Principle of Corresponding States, Equations of State: The van der Waals Equation of State, Cubic Equations of State, The Virial Equation of State, Equations of State for Liquids and Solids, Generalized Compressibility Charts, Determination of Parameters for Mixtures, The Thermodynamic Web, Joule-Thomson Expansion, Liquefaction.		
Assessment methods	Lecture Classes Lecture: written exam Classes: written test		
Recommended readings	1. M.D. Koretsky, Engineering and chemical thermodynamics, Wiley, New York, 2013, 2nd 2. H.D.B. Jenkins, Chemical Thermodynamics at Glance, Blackwell Publishing Ltd, Oxford, 2008		
Knowledge	Student demonstrates basic knowledge of thermodynamics.		
Skills	Student can solve calculation problems associated with thermodynamics.		
Other social competences	Student understands the need for continuous training and development in the field of process thermodynamics.		

Course title	TRANSPORT PHENOMENA		
Level of course	second cycle		
Teaching method	lecturing course / lecture		
Person responsible for the course	Halina Murasiewicz	**E-mail address to the person**	Halina.Murasiewicz@zut.edu.pl
Course code (if applicable)	WTiICh-2-85	**ECTS points**	4
Semester	winter/summer	**Language of instruction**	english
Hours per week	4	**Hours per semester**	60
Objectives of the course	The student will be able to: 1. Formulate governing equation for momentum, mass, and heat transfer. 2. Identify the terms describing storage, convection, diffusion, dispersion, and generation in the general governing equation for momentum, mass, and heat transfer. 3. Understand the various components needed for setting up conservation equations. 4. Utilize information obtained from solutions of the balance equations to solve chemical engineering problems. 5. Appreciate relevance of transport phenomena in chemical engineering.		
Entry requirements	Fundamentals of chemical engineering		
Course contents	Derivation of momentum conservation equations. Solving selected problems related to momentum transfer. Derivation of energy conservation equations. Solving selected problems related to energy transfer. Derivation of mass conservation equations. Solving selected problems related to mass transfer. Momentum transport: Viscosity; Mechanisms of momentum transport; Momentum balances; Velocity distributions in laminar and turbulent flow; Interphase transport of momentum in isothermal systems; Macroscopic balances for isothermal flow systems. Energy Transport: Mechanisms of energy transport; Thermal conductivity; Energy balances; Temperature distributions in solids; The equations of change for nonisothermal systems; Temperature distributions in turbulent flow; Interphase transport in nonisothermal systems; Macroscopic balances for nonisothermal systems. Mass transport: Mechanisms of mass transport; Diffusivity; Mass balances; Concentration distributions in solids. Equations of change for multicomponent systems; Concentration distributions in turbulent flow, Interphase transport; Macroscopic mass balances for multicomponent systems.		
Assessment methods	Lecture illustrated by Power Point presentation and computer simulation Classis illustrated by computer and manual calculations Periodic assessment of student achievement Lecture: exam at the end of the semester Classis: written test		
Recommended readings	1. Bird R.B., Stewart W.E., Lightfoot E.N., Transport Phenomena, Wiley, New York, 2007 2. Brodkey R.S., Hershey H.C., Transport phenomena. A unified approach, McGraw-Hill, New York, 1988 3. Kessler, David P. Greenkorn. Kessler D.P., Greenkorn R.A., Momentum, heat, and mass transfer fundamentals, Marcel Dekker, Basel, 1999		
Knowledge	The student will be able to understand the various components needed for setting up conservation equations.		
Skills	The student will be able to utilize information obtained from solutions of the balance equations to solve chemical engineering problems.		
Other social competences	The student will be able to appreciate relevance of transport phenomena in chemical engineering.		