FORM 2

1) Course teacher: Svjetlana Krištafor (Assistant Professor), Stjepan Milardović (Associate Professor), Ivana Steinberg (Assistant Professor)

2) Name of the course: General and Inorganic Chemistry

3) Study programme (undergraduate, graduate): Undergraduate

4) Status of the course: Basic

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. To apply acquired knowledge that is necessary for understanding other branches of chemistry.

2. To solve chemical problems based on fundamental chemical principles.

3. To demonstrate basic laboratory skills in handling chemical substances.

4. To analyse the structure of three different states of matter.

5. To argue the properties of individual elements with respect to the position of an element in the periodic table.

6. To identify stable and less stable (unstable) oxidation states of elements.

7. To conclude on the stability of hydrides and oxides of elements based on their electronegativity.

8. To conclude on the redox behaviour of the substance in elemental form based on standard reduction potential.

9. To conclude on the reactivity of elements in elemental form based their ionization energy.

10. To identify the compound based on its chemical formula and to write a chemical formula of inorganic compound based on its name.

6) Learning outcomes at the level of the study programme:

1. Basics of chemistry.

2. Basic laboratory skills and working standards in physical, chemical and biochemical labs.

3. Safe handling of chemicals and waste materials, their management and re-use.

4. Time planning and management

5. Monitoring and recording of environmental pollution by measurement of physical and chemical parameters and their systematic recording and documenting.

6. Collection, identification and interpreting of the information about samples or processes.

7. Methodology of theoretical interpretation of experimental results.

FORM 2

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Introduction to chemistry; Quantum world; Quantum mechanics.	The student will list the properties of matter and distinguish elements from compounds, pure substances from mixtures of substances. According to the modern theory of the atomic structure, the student will explain the uncertainty principle of quantum mechanics and outline the energy levels and forms of atomic orbitals. Based on the absorption and emission of electromagnetic radiation student will compare the ground and excited states of atoms.	- to identify the property as a chemical or physical, intensive or extensive - to distinguish molecules, atoms and ions - to describe the structure of atoms - to write the electronic configuration of neutral atoms and ions
2. Chemical bonds; Molecular shape and structure;	The student will identify covalent and ionic chemical bonds and give examples of covalent and ionic compounds. The student will define the valence and core electrons from the position of the element in periodic table. The student will write Lewis symbols of elements and apply them when drawing Lewis structures. Based on the quantum theory of chemical bonding, the student will sketch the energy levels of the molecules, write electronic configuration of molecules and estimate the	- to draw the Lewis structures of molecules and ions - to determine the dipole character and bonding (ionic or covalent) based on the electronegativity of elements - to predict the type, length and strength of chemical bonds - to distinguish the hybridization types and explain the difference between sigma and pi bonds

FORM 2

	molecular (non)stability.	
3. Gases, liquids and solids; Reaction thermodynamics; Physical and chemical equilibria; Chemical kinetics; Electrochemistry; Nuclear chemistry	The student will explain the difference between ideal and real gases and compare different states of matter based on the intermolecular interaction. The student will also explain the role of enthalpy in a chemical reaction, estimate (non)spontaneity of the process, determine the speed and order of chemical reaction and estimate its direction. The student will compare the acids and bases. The student will explain the different types of radioactive decay.	- to calculate *p*, *V*, *n* or *T* at defined conditions using gas laws - to outline and explain the types of intermolecular interactions - to calculate the change in enthalpy and Gibbs free energy of a chemical (electrochemical reaction) reaction - to calculate and analyse the chemical equilibrium constant - to calculate the pH of the solution - to write and balance the nuclear reaction equation
4. Inorganic chemistry Periodicity of chemical properties (electronegativity, ionization energy, electron affinity, oxidation numbers); The general atomic and physical properties of molecular hydrogen (preparation in industrial and laboratory scale); The 1st group of the elements (alkaline earth metals); The 2nd group of the elements (alkali metals)	The student will explain the periodic trends of the first ionization energy, electronegativity and atomic radii. The student will predict oxidation and reduction trends in periodic table based on standard reduction potentials. The student will compare reactivity of atomic and molecular hydrogen. The student will propose a suitable method for the hydrogen preparation (reduction of water, acid or base) based on standard reduction potential of the metal. The student will explain the typical reactions of alkali and	- to argue the questions based on application of theoretical principles -to solve the worked examples applying theoretical knowledge

FORM 2

	alkaline earth metals.	
The 13th group of the elements (boron group) The general chemical properties of the boron group of the elements. Properties of compounds (oxidation states in the range –3, –1, 0, +1, +2) The 14th group of the elements (carbon group) The general chemical properties of the carbon group of the elements. Preparation, physical and chemical properties of carbon (diamond, graphite, fullerene, graphene) CO and CO_2.	The student will recognize stable and less stable oxidation states based on electron configuration of elements. The student will conclude on stability of hydrides and oxides (13th group of elements) based on electronegativity data The student will explain the reactivity of aluminum in elemental state. The student will explain the preparation of polyborates by condensation of $B(OH)_3$. The student will conclude on reactivity in elemental states based on ionization energy. The student will analyse properties of compounds containing the elements in oxidation states –4,–2 and 0 (14th group of elements). The student will explain hydrolysis of tin and lead compounds. The student will explain the preparation of silicates by condensation of $Si(OH)_4$.	- to argue the questions based on application of theoretical principles -to solve the worked examples applying theoretical knowledge
The elements of 15th group (nitrogen group) The general chemical properties of the nitrogen group of the elements. The change of electronegativity along the group, properties of compounds (oxidation states in the range –3, –1, 0, +1, +3,	The student will conclude on the stability of hydro-oxides, -sulfides, -selenides and tellurides based on electronegativity. The student will conclude on the bond order and magnetic properties of oxygen, oxides, peroxides and superoxides	- to argue the questions based on application of theoretical principles -to solve the worked examples applying theoretical knowledge

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+5). Preparation, use and chemical properties of hydrides of nitrogen, phosphorus, arsenic, antimony and bismuth. The elements of 16th group (chalcogens) The general chemical properties of the chalcogens group of the elements. The properties of compounds (oxidation states in the range –2, –1, 0, +2, +3, +4,+6).	using MO diagram The student will conclude on the molecular and atomic oxygen reactivity. The student will compare the reactivity, acid-base stability and redox properties of ammonia, phosphine, arsine and bismuthine. The student will conclude on the bond order of N_2O, NO, NO_2, N_2O_3, N_2O_5 using MO diagram of nitrogen and oxygen.	
The elements of 17th group (the halogens) The general chemical properties of the halogen elements, physical and chemical trends along the group. Oxoacids and their salts (preparation and properties). The elements of 18th group (noble gases) Atomic and physical properties of noble gases. Preparation, production and use. Xenon compounds and derivatives of other noble gases.	The student will analyse the stability and bond order in diatomic halogen molecules using MO diagram. The student will conclude on the hydrohalous and hypohalous acid strength based on electronegativity. The student will draw the Lewis structure of halogen oxoacid and predict its strength.	- to argue the questions based on application of theoretical principles -to solve the worked examples applying theoretical knowledge
The properties of metals	The student will compare the stability of complexes of 3d, 4d and 5d elements. The student will analyse quantitatively electron	- to argue the questions based on application of theoretical principles -to solve the worked examples applying theoretical

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	absorption spectra of various dn systems. The student will describe the magnetic properties of metallic complexes and their colour.	knowledge

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FORM 2

1) Course teachers: Assoc. prof. dr. sc. Ana Lončarić Božić, Assoc. prof. dr. sc. Ana Vrsalović Presečki

2) Name of the course: Introduction to enviromental engineering

3) Study programme (undergraduate, graduate): undergraduate

4) Status of the course: mandatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. Understand the correlation between anthropogenic activities and environmental pollution problems and be acquainted with the mitigation measures in relation with different emissions

2. Understand the opportunities of preventive approach in environmental protection and management

3. Adopt the main principles and methodology of preventive strategies as environmental engineering tools

4. List and explain the objectives of the scientific disciplines environmental engineering
5. Explain the importance of learning courses, which are the integral part of the study program "Environmental engineering"
6. Explain the importance of eco-technology

6) Learning outcomes at the level of the study programme:

1. Critical analysis of environmental problems
2. Recognize the necessity of getting knowledge from different scientific disciplines in order to successfully solve environmental problems

3. Basics of fundamental environmental engineering knowledge

4. Basics of professional protection of local and global environment, environmental development and control, and environmental legislation for water, air and soil protection

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Environment - concepts, problems, principles of environmental protection	- explain concepts related to the environment	- define the terms biosphere, technosphere and ecosystem - explain the causes and consequences of environmental pollution - list the objectives and principles of environmental protection - define sustainable

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		development
2. Anthropogenic and natural environmental pollution sources	- understand the correlation between anthropogenic activities and environmental pollution problems -be acquainted with the mitigation measures in relation with different emissions	- define the types of pollution sources according to different criteria -list the main pollution sources and explain the correlation with air, soil and water pollution -define and explain the terms: hydrological cycle, water pollution, eutrophication, greenhouse gasses, global warming potential tropospheric and stratospheric ozone, mechanisms transportation and transformation of soil pollutants -specify environmental and human health problems mitigation measures related to the particular the emissions
3. Preventive approach in environmental protection and management	-understand the opportunities of preventive approach in environmental protection and management -adopt the main principles and methodology of preventive strategies as environmental engineering tools	-explain the historical development and adoption of preventive approach in environmental engineering practice -define the main principles and specify elements of preventive environmental management tools such as cleaner production, eco-design and environmental management systems,
4. Environmental engineering , eco-technology	- list and explain the objectives of the scientific disciplines environmental engineering - explain the importance of learning courses, which are the integral part of the study program "Environmental engineering" - explain the importance of eco-technology	- define environmental engineering - specify the goals of environmental engineering - list the knowledge that environmental engineer required - define the role of the necessary knowledge in environmental engineering - define eco-technology - distinguish eco-technology and other technologies

FORM 2

English language (basic course)

COURSE AIM: Gaining competences like reading, oral and written fluency in the English language related to chemistry. Individual classification of new vocabulary by using the on-line dictionaries to acquire correct pronunciation and placing it in the e-class glossary. As part of the course students will infer basic vocabulary of chemical terminology in English, adjectives that describe the various states of matter, compounds and solutions, and ways in which they can read chemical equations, rules when to use the definite article and the indefinite articles. The students will also demonstrate the rules pertaining to the order of adjectives in a sentence, the comparison of adjectives and superlative form of adjectives and adverbs. They will also illustrate how to write a CV, do the revision tests on their own in the e-class, take part in group work and put their group work in the e-portfolio.

DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES OF THE STUDENTS:

General competencies: pronunciation of basic chemistry elements and names of compounds, acids, molecules and reading of numbers, equations as well as naming the ionic compounds in English.

Specific competencies: describing the characteristics of a material by using adjectives, use of suffixes and prefixes, comparison of adjectives, adverbs and linking words.

STUDENT OBLIGATIONS: The students are obliged to attend classes and are to put their CV in their e-portfolio (Euro pass CV). They are obliged to practice solving the revision tests to prepare for the midterm tests. They become eligible to attend the midterm tests by attending class regularly. Students must have their indexes or ID cards in order to take part in written tests. If they are not eligible to attend the midterm tests then they have to take the final written and oral tests at the end of the second semester. The oral test refers to the lab experiment they did as a group which should be in their e-portfolio. They have to orally explain the lab report in order to get a final grade.

SIGNATURE REQUIREMENTS: The students must attend 80 percent of all classes and take part in the language exercises during class, write their CV (Euro pass CV) and put their group work and CV in the e-portfolio. They are to pass the revision tests in the e-class on their own. They have to pass all written and oral exams for the final grade.

TEACHING METHOD: lectures, individual work on the e-class and e-portfolio, language exercises such as reading, pronunciation, answering questions, pair work, group work, use of computer and consultations according to necessity.

METHOD OF ASSESSMENT:

Written midterm tests (60 percent or more on both midterm tests) and e-portfolio content
Written final exam (minimum 60 percent to pass) and oral exam (presentation of lab experiment conducted at the University and filmed) which is linked to the filmed lab experiment group work in their e-portfolio.

QUALITY CONTROL AND SUCCESS OF COURSE: anonymous student survey

METHOD PREREQUISITES:

Access to a computer and knowledge of e-class and e-portfolio passwords in the Moodle and Merlin programs.

COURSE LEARNING OUTCOMES:

1 students will generate basic concepts of chemistry terminology in English
2 students will explain new vocabulary and demonstrate pronunciation of it by learning it on
their own with the aid of on-line dictionaries

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3 students will demonstrate how to use the e-portfolio at the beginners level
4 students will examine the additional materials in the e-class
5 students will prepare for the midterm tests by practicing the revision tests in the e-class

PROGRAM LEARNING OUTCOMES:

1 students will interpret the expert terminology used in the field of chemistry today
2 students will generate use of English grammar at the beginners level
3 students will write their own Euro pass CV in English and put it in their e-portfolio
4 students will use the e-class and e-portfolio programs on their own

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English language (advanced course)

COURSE AIM: To gain competencies for advanced reading, oral and written correspondence in the English professional language of the students trait. Independent learning of new vocabulary by using the on line dictionaries that also provide US and UK pronunciation. The students will know how to apply basic technical terminology and learn to negotiate in English. Preparing the students for oral presentations in English for future international conferences. Students will have mastered the basic technical terminology in English during this course. Students will also become familiar with some of the customs of the United States and the United Kingdom.

THE DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES OF STUDENTS:

General competencies: pronunciation of specific terminology that is related to various branches of technology in English.

Specific competencies: writing their own CV and seminar paper. Correct use of grammar.

STUDENT OBLIGATIONS: Students are required to attend lectures and are obliged to place their Euro pass CV in their e-portfolio. They are also expected to solve the revision tests in their e-class. They have to attend the midterm tests if they are eligible to do so, depending on their attendance record. They are obliged to bring their Index or ID card to class during midterm and final tests.

SIGNATURE ELIGABILITY: In order to get a signature at the end of each semester the student must be present in class for 80 percent of the lectures and take part in the exercises during class, write their CV and correct it, place their CV in their E-portfolio.

The student must pass midterm exam 1.

MANNER OF TEACHING: lectures, language exercises (reading, pronunciation, understanding, speaking), independent learning (e-class), pair work, group work, individual answering questions related to the subject matter, grammar exercises and consultations if need be.

ASSESSMENT MANNER AND EXAMINATION:

Written tests (minimum of 60 percent or more scored on each midterm test excuses the student from having to take the final written and oral tests). They also have to have both seminar papers in the e-portfolio in order to get the final grade.

Written test (minimum of 60 percent in order to pass) and oral test (explanation of lab experiment)

QUALITY CONTROL AND COURSE SUCCESS: anonymous student survey

METHOD PREREQUISITES:

Access to a computer and knowledge of password to access e-class and e-portfolio in the Moodlu or Merlin programs. Each student has to have their access code to enter these programs.

LEARNING OUTCOMES OF THE COURSE:

1 students will describe basic concepts of technology and summarize the terminology in English

2 students will individually learn and be able to repeat the pronunciation of new vocabulary

3 students will practice using the e-portfolio at an advanced level

4 students will individually examine the additional material in the e-class

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5 students will individually prepare themselves for the midterm tests by reviewing the revision
tests in their e-class

LEARNING OUTCOMES AT PROGRAM LEVEL:

1 students will recognize expert terminology used in their field of technological expertise
2 students will demonstrate use of English grammar at the advanced level
3 students will demonstrate how to write a CV in English (Euro pass CV) and a lab report
4 students will practice the use of the e-portfolio and e-class programs on the computer

FORM 2

1) Course teacher: dr. sc. Miroslav Jerković, Assistant Professor

2) Name of the course: Mathematics I

3) Study programme (undergraduate, graduate): undergraduate

4) Status of the course: obligatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. Distinguish and correctly use various number structures, their notation and available operations.

2. Apply coordinate systems (plane, space and higher-dimensional) and corresponding basic mathematical constructions: vectors, matrices and systems of linear equations.

3. Use elementary functions, distinguish their graphs and be able to interpret the corresponding relationship between dependent variables.

4. Master the notion of derivative, as well its physical and geometrical interpretation. Be competent to apply the notion of derivative to model and solve practical problems.

5. Actively use the corresponding basic procedures in program packages Mathematica or Matlab.

6) Learning outcomes at the level of the study programme:

1. Apply obtained competence in using numbers for quantitative description of physical properties.

2. Use the knowledge of coordinate systems, matrices and vectors to model engeneering problems.

3. Apply functions and their derivations in analysis of engineering problems.

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Real and complex numbers	- distinguish natural, integer, rational, real and complex numbers and their notation - calculate with real numbers, their approximate values, and learn to estimate their values - understand relations among	- for a given number, determine the number type, its value, its value and equivalent notation, as well as learn how to represent it geometrically - execute given operations

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	numbers by being able to solve simple equations and inequalities - apply numbers for writing down the values of physical quantities	with numbers algebraically and numerically, exactly and approximately - determine the relation among the given numbers, set and solve a simple equation and inequality - interpret a connection among the given physical quantities, as well as among their numerical values
2. Two-dimensional, three-dimensional and n-dimensional real vector space	- define and graphically represent a coordinate system on a line, in plane and in space, as well as understand the generalization to higher dimensions - apply the notion of coordinate system to represent geometrical and physical relation between various quantities - define analitically a notion of vector in real vector space, use various equivalent notations and be able to use operations on vectors - interpret vector and its components form the engineering point of view (forces, velocity etc.)	- represent a point or a set of points, given by their coordinate values - write down the analytical expression representing a geometrical or physical relation between quantities - execute given vector operations
3. Some transformations of plane and space – the notion of matrices and linear operators	- define matrix and its elements - apply vectors and matrices to write down some basic transformations of plane and space: symmetry, projection, translation, rotation - distinguish various types of matrices: square matrix, symmetric matrix, diagonal	- determine columns, rows, elements, type and order of a given matrix - determine the matrix representation of a given transformation, or, vice versa, determine the transformation out of a given matrix representation - determine the type of a

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	matrix etc.	given matrix
4. Algebra of matrices. Inverse matrix and determinant	- define operations with square matrices, be able to use these operations and compare them with number operations - define the notion of inverse matrix and its state its properties - define the matrix determinant for matrices of second and third order	- execute the given matrix operations - calculate the determinant of a given matrix of second or third order
5. Scalar, vector and mixed product of vectors	- geometrically define the angle between two vectors - define and calculate the scalar product of vectors, and establish a relationship with the notion of angle between two vectors - analitically, geometrically and physically define the vector product; learn to calculate it and use it to find the area given by two vectors - define the mixed product, calculate it and use it to find the volume determined by three vectors	- represent a relation between two vectors, regarding the angle between them - write down the formulas for scalar product of vectors and for the angle between vectors, and apply them to given vectors - write down the formulas for vector and mixed product of vectors, and apply these formulas to given vectors
6. Systems of linear equations and solution methods	- define the notion of a system of linear equations, and its set of solutions - define and apply the matrix notation for a system of linear equations - solve some simple systems by using, where appropriate, the inverse matrix method, Cramer rule or the Gauss-Jordan method - calculate the determinant	- write a matrix notation of a given linear system - solve a given system using the required, or appropriate, method - calculate the determinant and inverse of a given matrix, using elementary matrix operations

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	and inverse of a square matrix, by using the elementary matrix operations	
7. Notion and geometrical meaning of eigenvalues and eigenvectors (not obligatory)	- define the notions of eigenvalue and eigenvector of a matrix - interpret geometrically and physically these two notions - determine eigenvalues and eigenvectors in concrete examples - explain the special role of symmetric matrices	- check if a given number (vector) is an eigenvalue (eigenvector) of a given matrix - determine and interpret the eigenvalues and eigenvectors of a given matrix of second order
8. Notion of function, its graph and inverse function	- present the notion of a function and interpret it as an operation and notation of a relation between dependent quantities - define the notion of a graph of function and the notion of a graph equation - state basic properties of functions and graphical interpretion of these properties - define the inverse function, its graph and sketch the connection to equation solving	- calculate the values of a given function and represent those values as points of its graph - determine the value of a given function by using its graph - interpret the properties of a function if its graph is given and vice versa, represent graphically a function with specific property - present a graphical solution of a given equation and estimate the solution graphically
9. Elementary functions. Functions important in engineering and natural sciences.	- define the notion of elementary function, give a list of elementary functions and their inverse functions - represent graphically basic elementary functions and their inverse functions (powers and roots, exponential and logarithmic functions, trigonometric and arcus functions)	- calculate the values of a given elementary function - sketch the graph of a given basic elementary function - solve a given equation (exponential, logarithmic, trigonometric etc.) exactly, as well as approximately

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	- graphically interpret important properties of elementary functions (growth and decline, extremes, convexity and concavity, inflection points) - solve equations related to basic elementary functions - sketch the importance of applying elementary functions on engineering problems	
10. Notion of sequence, limit of a sequence and limit of a function	- define the notion of sequence of numbers and its series, as well as the notion of limit - approximately and exactly determine the limit of some important sequences - define and graphically represent the limit of a function - state some important limits of functions	- determine and write down the expression for the general term of a simple sequence given by its first few terms - calculate the limit of a given sequence - calculate the limit of a given function
11. Notion of derivative, its geometrical and physical meaning	- present the analytical definition of point derivative of a function, as well as its functional derivative - intepret the derivative physically (notion of velocity) - intepret the derivative geometrically (notion of inclination) - approximately determine the value of derivative by using the graph of a function - use the definition of a derivative to obtain the derivatives of some simple functions (as for power or	- using the definition of derivative, find derivatives of some basic functions, as for square root or square power - using the graphical representation, estimate the relative speed of change of one quantity, as compared to the other quantity

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	root functions)	
12. Properties of derivative. Derivatives of elementary functions	- state the properties of functional derivatives and use them to calculate the derivatives - list the derivatives of basic elementary functions - calculate the derivatives of basic elementary functions (power function, exponential function, sinus and cosinus functions and their inverses)	- by using the table of derivatives, as well as the properties of the derivative operation, find the derivative of a given polynomial, a product or quotient of given elementary functions - find the derivative of a function composed out of given functions from the table of derivatives
13. Linear and quadratic approximation. Taylor series	- list and apply formulas for linear and quadratic approximation of a function - geometrically and analytically interpret linear approximation - derive the formula for the tangent line in a point of a graph of a function, and be able to interpret it geometrically - state the general formula for Taylor series of a function, and present the Taylor series for some basic elementary functions - apply Taylor series to approximately calculate values of a given function	- use the linear and quadratic approximations, as well as Taylor series, to calculate the approximate values of a given function - determine linear and quadratic approximations and the Taylor series for x0=0 for the following functions: exp(x), sin(x), cos(x), 1/(1-x)
14. Increasing and decreasing functions, convexity and concavity, inflection points and their physical meaning	- interpret increse and decrease of a function, as well as local extremes, by using the notion of first derivative, and apply this interpretation to a given problem - inetrpret convexity and concavity, as well as inflection points, by using the	- apply to a given function

FORM 2

	notion of second derivative, and apply this interpretation to a given problem - distinguish necessary and sufficient conditions in terms of derivatives, for a function to have a specific property stated above	
15. Qualitative analysis of a function by using a notion of derivative.	- use the competence obtained in Teaching unit 14 to some more involved functions	

FORM 2

1) Course teacher: dr. sc. Vesna Volovšek, full professor

2) Name of the course: Physics I

3) Study programme (undergraduate, graduate): undergraduate

4) Status of the course: mandatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. Explaining the physical processes and phenomena
2. Analyzing and solving physical problems using mathematical skills (mathematical formulation of physical problems)
3. Graphical representation of the laws of physics
4. Interpretation of the obtained results
5. Relating the acquired knowledge in solving physical problems

6) Learning outcomes at the level of the study programme:

1. Ability to apply the lows of physics
2. Acquiring computational skills
3. Correlating the acquired knowledge
4. Application of scientific methods in solving problems
5. Deductive and inductive reasoning

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Kinematics	- to describe different kinds of motion through kinematic quantities (position, velocity, acceleration)	- Explaining physical concept - Mathematical formulation of physical problem - Describing the model and its restrictions
2. Dynamics	- to interpret and apply Newton's lows and the lows of conservation of linear and angular momentum - to establish the equation of motion - to explain the relationship between different dynamic	- Explaining physical concept - Mathematical formulation of physical problem - Describing the model and its restrictions

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	quantities (force, linear momentum, angular momentum, impulse, torque)	
	- to recognize some fundamental forces in nature (Gravity)	
3. Work and Energy	- to explain the relationship between work, potential and kinetic energy - to interpret and apply the law of conservation of energy - to derive the potential energy for some conservative forces with their grafical representation	- Explaining physical concept - Mathematical formulation of physical problem - Describing the model and its restrictions
4. Oscillations and Waves	- to describe simple harmonic motion and apply its equiation to different periodic motions in nature -to describe different kinds of waves by means of characteristic quantities (wavelength, period, frequency, angular frequency, amplitude)	- Explaining physical concept - Mathematical formulation of physical problem - Describing the model and its restrictions
5. Heat and Temperature	- to explain relationship between different thermodinamic quantities (heat, temperature, pressure, volume, internal energy, entropy) through thermodynamical and statistical approach. - to derive the work done in different thermodynamic processes	- Explaining physical concept - Mathematical formulation of physical problem - Describing the model and its restrictions

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FORM 2

1) Course teacher: Marinko Markić

2) Name of the course: Applied Computer Sciences

3) Study programme (undergraduate, graduate):undergraduate

4) Status of the course: obligatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. Decribe the structure and computer basic
2. Solve simple programming problems using structured programming
3. Solve simple problems applying Matlab software package
4. Use of Mathematica in solving problematic practical tasks
5. Explain the concept of database and database management system
6. Explain the formation of relational databases
7. Apply the MS Access to work with relational database
8. Collect information from online databases.

6) Learning outcomes at the level of the study programme:

1. Basic of computing, programming
2. Basic of use of databases and basic concepts of the relational and statistical databases
3. Information retrieval through on-line computer searches

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1.Programming Basic	- Explain the concept and basic properties of the algorithm - Apply an algorithm flow chart - Identify the program development phase	- Apply the principles of structured programming for the development of standard algorithms - Draw a flow chart of the developed algorithm-

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	- Apply standard algorithms for: computing the mean numbers, search the smallest and the largest among the numbers, working with natural numbers (addition, multiplication, computing factorial, divisibility number with the default number), replace the contents of variables, sorting array elements (Bubble sort) -	
2. Matlab Basic and Matlab programming	-- Distinguish the data types - Describe working with arrays, vectors and matrices Apply selection structures - Use data entry and printing - Write mathematical expressions with the use of arithmetic, relational and logical operator and appropriate functions, including M-functions - Apply command decisions (single, multiple if statement) - Apply repetition structures (for-end, while-end, nested) - Graphically display data - Applying commands for saving and loading data	-Define and explain the data types in Matlab, (floating point and single and double precision numbers) - Define variables in Matlab, their distribution - Describe the definition of a series of numbers in Matlab, commands linspace and logspace, - Specify commands for drawing two-dimensional graphs in Matlab and their syntax, specify commands to draw more coordinate system or system within the same graphic windows and their syntax, - Write a program in Matlab script file which includes: data entry, use variables, the assignment statement, arithmetic operations, relational and logical operators, work with arrays, vectors and matrices, application functions, command decisions, repetition, print the results, save results to the file, draw a graph,

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3. Elementary Programming in Mathematica	- distinguish between variables and constants - distinguish between symbolic and numerical calculation - Apply command accession, entry and print data - Write mathematical expressions with the use of arithmetic, relational and logical operators and the corresponding function - Apply the lists (vectors and matrices) - Apply the symbolic calculation: linear algebra, simplification of symbolic expressions, substitution values for symbols, working with user-defined functions, deferred evaluation, symbolic solving algebraic and linear differential equations, differentiation and integration of symbolic expressions, calculating limits of the function and development functions in Taylor series - Apply decisions command (single, multiple if statement) - Apply repetition structures (For, Do-While) - Apply graphical display of functions and data - Use dynamic interaction (command Manipulate)	- Write a program in Mathematica including: data input/ouput, use variables, use of decision, arithmetic operators, relational and logical operators, working with lists (vectors and matrices), use functions, command decisions, Repetition, graphical representation of a function or data, the use of dynamic interaction, print the results on the screen or to a file, all with the use of basic commands and functions in Mathematica - Write a program in Mathematica with the use of symbolic calculation in linear algebra, simplification of symbolic expressions, substitution values for symbols, working with user-defined functions, deferred evaluation, symbolic solving algebraic and linear differential equations, differentiation and integration of symbolic expressions, the calculation of the limit function and development functions in Taylor series - Compare result obtained with a numerical calculus and the solutions obtained with symbolic calculation. - Test program and remove all syntax and logical errors
4. Relation Database Concepts	- Describe the basic concepts of data and information - Define the database and database management system - Explain the concept of	- Explain the basic concepts and distinguish data from information - Explain the concept of database and database management system -Describe and give an

FORM 2

	relational database - Create a simple Entity-relationship model - Create a simple relational model - Identify the dependencies - Apply the process of normalization to the third normal form - Distinguish sequential, direct and index method of data access	example of a relational database and to compare it with the flatbed database - Analyse or draw a simple Entity-relationship diagram (Chen and Martin's view) - Analyse or develop a simple relational model - Indicate the functional dependencies in relational model - Analyse the relations and rearrange using normalization process to the default normal forms (first, second or third) - Give examples of sequential, direct and index access methods to data and to compare the advantages and disadvantages of indexing
5. MS Access Basic	- Explain the basic concept - Create tables, forms, queries and reports - Modify tables, forms, queries and reports - Connect table - Handle the data in the database (view, add, delete and modify data) - Collect data (information) from the database using queries and sorting tools	- For the given database scheme create a database in MS Access - Create forms and use them to enter (add) data into the database, browse, delete and modify data - Create simple and complex search queries - Create reports and use them to display data which are located in tables or obtained as a result of search
7. Scientific resources on the Internet	- Define basic concepts of data and information - Define basic concept of a database - Collect information from databases on the Internet - Evaluate the relevance of the collected data	- Apply the keywords and logical operators in searching databases on the Internet - Compare the data collected from the internet with respect to their source - Argue the use of the data obtained

FORM 2

	- Develop a critical attitude towards the source of the data collected	
8. Statistic Database	- Distinguish between data, metadata, information and knowledge - Explain the concept of statistical database - Distinguish between relational database and statistical database - Specify the way of processing data	- Describe an example of design data in statistical database - List the steps in knowledge discovery in data with specification of the methods of data processing

FORM 2

1) Course teacher: prof. dr. sc. Ivica Gusić, Full Professor / dr. sc. Miroslav Jerković, Assistant Professor

2) Name of the course: Mathematics II

3) Study programme (undergraduate, graduate): undergraduate

4) Status of the course: obligatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. Apply indefinite integral to problems inverse to the derivative problem
2. Use definite integral to solve the problem of area and apply it in solving engineering problems
3. Adopt the notion of a function of several variables, its derivatives and integral, and apply it to study the relations among several dependent quantities
4. Use differential equations of first and second orders to solve mathematical and physical problems
5. Actively use the corresponding basic procedures in program packages Mathematica or Matlab.

6) Learning outcomes at the level of the study programme:

1. Apply the indefinite and definite integrals to model an engineering problem.
2. Apply the differential calculus of functions of several variables to model an engineering problem.
3. Use ordinary and partial differential equations to model an engineering problem.

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Indefinite integral and computation methods.	- define the primitive function and indefinite integral of a function - show competence in using the basic properties of indefinite integral, and in applying them in calculations - apply methods of partial integration and substitution	- for a given elementary function determine a primitive function - check if a give function is a primitive function of a given function - introduce an appropriate substitution to a given integral

FORM 2

	- apply indefinite integral to solving some simple engineering problems	- derive the differential equation of radioactive decay and solve it by integration - derive the differential equation of the vertical shot and solve it by integration
2. The area problem – definite integral. Leibnitz-Newton formula.	- establish a connection between the problem of area under curve and the notion of definite integral - interpret geometrically and estimate the definite integral for a positive, as well as for a general function - calculate the definite integral by using the Leibnitz-Newton formula - sketch and geometrically interpret the properties of definite integral	- represent geometrically and estimate the value of the definite integral of a given simple function - calculate the value of the definite integral of a given simple function
3. Methods for calculating the definite integral. Improper integral.	- derive and apply the formula for partial integration of the definite integral - derive and apply the formula for integration by substitution of the definite integral - define and represent graphically the improper integral - calculate the given improper integral	- using the method of partial integration, calculate the appropriate definite integral - using the method of substitution, calculate the appropriate definite integral - calculate and represent graphically the improper integral of a given function
4. Geometric application of definite integral.	- use the definite integral to calculate the area of plane domain - derive and apply the formula for volume of the rotational body	- represent graphically, estimate and calculate the area of a plane domain bounded by given curves - calculate the volume of a ball - calculate the volume of a

FORM 2

		cone
5. Application of definite integral to natural sciences.	- apply the definite integral to calculate the mass, barycentre and moment of inertia of a nonhomogeneous line segment with a given mass density function - explain above formulas - use the definite integral to interpret the problem of a work of a line force	- calculate the mass of a nonhomogeneous segment with a given mass density function - estimate and calculate the barycentre of a nonhomogeneous segment with a given mass density function; interpret the result - calculate the moment of inertia for a nonhomogeneous segment with a given mass density function - calculate the work of a line force given by F(x)=-kx; interpret the result
6. Notion of a function of two variables, its graph and partial derivatives.	- define a function of two variables and apply it to the problem of a relation among three dependent quantities - determine the domain of a function of two variables, and evaluate it - define and calculate the partial derivatives of first and second order for a function of two variables - physically and geometrically interpret the first order partial derivatives at a given point of a function of two variables	- determine the natural domain of a given function of two variables - determine partial derivatives and partial derivatives at a particular point for a given function of two variables
7. Linear and quadratic approximation of a function of several variables.	- write down the formula for linear approximation of a function of two variables and comment on analogy with the case of single variable - apply linear approximation to calculate the approximate	- determine linear and quadratic approximation for a given function of two variables - determine the increment and approximate increment for a given function of two

FORM 2

	values - write down the formulas for increment and approximate increment of a function of two variables and comment on analogy with the case of single variable - apply the formula for the approximate increment of a function - write down and apply the formula for quadratic approximation of a function of two variables	variables
8. Local extremes of a function of several variables.	- define the local extremes for a function of two variables and comment on analogy with single variable case - state and explain the necessary conditions for local extremes - apply the above criterion, by using partial derivatives of first and second order - apply the above criterion to solve some mathematical and engineering problems (the minimization problem)	- determine the local extremes for a given function of two variables - apply the local extreme criterion to solve a given minimization problem
9. Multiple integrals – consecutive integration.	- define the notion of definite integral for a positive function of two variables along the plane domain, and interpret it as a volume - by using the formula for consecutive integration, calculate the definite integral on the given domain - define and calculate the definite integral of a general function	- represent graphically the integral of a given positive function of two variables - calculate the integral of a given function of two variables, over a given plane domain - introduce the appropriate polar substitution in a given integral

FORM 2

	- apply polar coordinates to calculate the definite integral of a function of two variables.	
10. Application of the multiple integral.	- interpret the distribution of mass for a nonhomogeneous plane domain using the mass density function - sketch the derivation of the formula for the mass of a nonhomogeneous plane domain using its mass density function - apply formulas for determining the mass and barycentre of a nonhomogeneous plane domain	- calculate the mass of a given nonhomogeneous plane domain - estimate and calculate the barycentre of a given nonhomogeneous plane domain
11. The notion of ordinary differential equation, integral curve and initial conditions.	- state the general form of ordinary differential equations of first and second order - define the general and particular solutions - solve some simple differential equations and graphically represent the solution via integral curves - define initial conditions and their role	- determine the order of a given differential equation - check if a given function represents a solution of a given differential equation - find and represent graphically the general solution of a given simple differential equation
12. Application of ordinary differential equations. Cauchy's problem.	- state and solve the Cauchy problems of first and second order and interpret them physically	- derive and solve the Cacuhy problem of cooling (heating) - derive and solve the Cauchy problem of linear motion with constant force applied - derive the Cauchy problem of a oscillation of a particle along a line
13. Methods for solving some types of first and second	- apply the method of	- solve a given differential equation of first or second

FORM 2

order ordinary differential equations.	variable separation - state and solve homogeneous and nonhomogeneous linear differential equation of first order - state and solve homogeneous and nonhomogeneous linear differential equation of second order with constant coefficients	order - solve the Cauchy problem of a oscillation of a particle along a line; interpret the solution
14. The notion of partial differential equation, its solution and initial and boundary conditions.	- state the general form of partial differential equations of first and second order - define and physically interpret initial and boundary conditions	
15. Application of partial differential equations (not obligatory).	- state the differential equations for vibration of a string and heat conduction, together with the corresponding initial and boundary conditions	

FORM 2

1) Course teacher: dr. sc. Vesna Volovšek, full professor

2) Name of the course: Physics II

3) Study programme (undergraduate, graduate): undergraduate

4) Status of the course: mandatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. Explaining the physical processes and phenomena
2. Analyzing and solving physical problems using mathematical skills (mathematical formulation of physical problems)
3. Graphical representation of the laws of physics
4. Interpretation of the obtained results
5. Relating the acquired knowledge in solving physical problems

6) Learning outcomes at the level of the study programme:

1. Ability to apply the lows of physics
2. Acquiring computational skills
3. Correlating the acquired knowledge
4. Application of scientific methods in solving problems
5. Deductive and inductive reasoning

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	**Learning outcomes**	**Evaluation criteria**
1. Electrostatics	- to describe different kinds of electric phenomena and interactions through electrostatic quantities (charge, Coulomb force, electrostatic energy, potential and voltage, electric current)	- Explaining physical concept - Mathematical formulation of physical problem - Describing the model and its restrictions
2. Magnetostatics	- to explain the origin of magnetic phenomena and interactions and to establish the conections between different quantities (magnetic field, electric current, Lorentz force)	- Explaining physical concept - Mathematical formulation of physical problem - Describing the model and its restrictions

FORM 2

3. Alternating electric and magnetic fields	- to explain the relationship between alternating electric and magnetic fields - to describe the applications (alternating current, electromagnetic waves)	- Explaining physical concept - Mathematical formulation of physical problem - Describing the model and its restrictions
4. Optics	- to explain and apply the laws of geometric and wave optics to different optical instruments (mirrors, lenses, gratings)	- Explaining physical concept - Mathematical formulation of physical problem - Describing the model and its restrictions
5. Fundamental principles of quantum physics	- to explain differences between classical and quantum quantities - to apply quantum mechanical description to some phenomena in micro world	- Explaining physical concept - Mathematical formulation of physical problem - Describing the model and its restrictions

FORM 2

1) Course teacher: Tomislav Bolanča

2) Name of the course: Analytical Chemistry

3) Study programme (undergraduate, graduate): undergraduate study – Ecoengineering

4) Status of the course: obligatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. To define analytical system.
2. To relate principles of chemical equilibrium with methodology of analysis in environmental.
3. To apply methods of selective separation of inorganic anions and cations in chemical analysis of environment and environmental processes.
4. To apply methods of gravimetric analysis in chemical analysis of environment and environmental processes.
5. To apply methods of volumetric analysis in chemical analysis of environment and environmental processes.

6) Learning outcomes at the level of the study programme:

1. To apply basic knowledge of chemistry.
2. To develop ability of technologies' analyses.
3. To develop basic laboratory skins and define working rules in chemical laboratories
4. To track and monitor environment pollutions by measuring chemical indicators.
5. To demonstrate methodology of analytical process.

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Analytical system	- To define analytical system	- To define analytical method. - To determine analytical signal and calculate analytical result. - To express significant digits.

FORM 2

		- To differentiate accuracy and precision of analytical methods.
2. Qualitative chemical analysis in ecoengineering	- To relate principles of chemical equilibrium with methodology of chemical analysis of environment and analysis of environmental processes. - To apply methods of selective separation of inorganic anions and cations in chemical analysis of environment and analysis of environmental processes.	- To compute solution's pH value. - To compute conditions of inorganic salts precipitation. - To compute conditions of complex formation - To compute redox potential - To plan systematic analysis of cations and anions - To compute possibility for executing the planed systematic analysis - To apply principles of dissolution of inorganic salts
3. Quantitative chemical analysis in ecoengineering	- To relate principles of chemical equilibrium with methodology of chemical analysis of environment and analysis of environmental processes. - To apply methods of gravimetric analysis in chemical analysis of environment and environmental processes. - To apply methods of volumetric analysis in chemical analysis of environment and environmental processes.	- To plan the steps of gravimetric analysis - To classify contaminations of precipitate - To explain how to prevent contaminations of precipitate - To describe possibilities of treatment for purification of contaminated precipitate - To differentiate properties of precipitate according tothe particle size - To compute result in gravimetric analysis

FORM 2

		- To plan steps in volumetric analysis - To differentiate end-point and equivalence point in titration - To select indicator and method for detection of titration end-point. - To compute result of volumetric analysis - To compute all points on titration curve

FORM 2

1) Course teacher: Prof. Marija Vuković Domanovac, PhD

2) Name of the course: Microbiology

3) Study programme (undergraduate, graduate): undergraduate

4) Status of the course: obligatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. to define the bacteria, eukaryotes and Archaea

2. to give examples of structurally diverse microorganisms and sort microorganisms in their energy metabolism and carbon sources

3. to choose the method of cultivation, enrichment and prevention of microbial growth

4. to explain the different circular path of the substance on Earth involving microorganisms

5. to choose a method of removing pollutants based on the biogeochemical cycling of matter on Earth

6) Learning outcomes at the level of the study programme:

1. isolate and identify microorganisms present in the selected ecosystem

2. analyze the conditions for optimum growth of microorganisms isolated

3. adapted microorganisms for faster decomposition of pollutants in the environment or the synthesis of specific products

4. select micro-organisms and apply them in engineering environment, chemical and related industries

5. apply the models of growth of microorganisms and evaluated for their effectiveness

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. The molecules of living systems	- to list of which parts macromolecules consist, indicate and sketch the chemical bond - to explain the function of macromolecules in living organisms	- explain the structure and function of macromolecules - compare the differences in the structure and function of two nucleic acids
2. The microscope, study of microorganism's structure	- to indicate parts of the microscope and explain the structure of the lens and the power of their separation	- recognize optical and mechanical parts the microscope - describe and sketch default

FORM 2

	- to outline the structure of microbial cells - to prepare preparations of microorganisms for microscopy and determine the size of the cells - to distinguish easily from a complex painting of bacterial cells	microorganism observed under the microscope - perform a calibration of the lens, calculate the magnification factor and measure the size of the observed cells - explain the difference between gram-positive and gram-negative bacteria
3. The structure and function of prokaryotic and eukaryotic cells	- to describe the structure and function of prokaryotic cells - to explain the mass transfer through the membrane - to describe the formation of spores and pigments - to identify a group of gram-negative aerobic and faculty anaerobic rods and gram-positive cocci - to compare the structure of prokaryotic and eukaryotic cells - to describe the structure Arhaee - to indicate characteristics of fungi and describe ways of reproduction - to identify representatives of certain grades of fungi, protozoa, algae and lichen	- explain the function and chemical structure of certain parts of the bacterial cells - indicate difference between passive and active transport across membranes - analyze the impact of environmental factors on the formation of spores and bacteria in pigment - explain the characteristics of the industrial and ecologically important gram-negative and gram-positive bacteria - to outline and label parts of prokaryotic and eukaryotic cells - summarize the differences between the bacteria, eukaryotes and Arhaee - describe the differences in sexual, asexual and vegetative propagation of fungi - describe the characteristics of the given group of fungi, protozoa, algae and lichens and point out their importance in industry and environment

FORM 2

4. Enzymes, reaction mechanisms, energy metabolism, and pathways of production and utilization of energy	- to define the function of enzymes, explain the chemical structure and structure of the enzyme - to outline scheme of enzymatic reactions - to select the factors that inhibit the enzymatic activity - to explain the oxidation-reduction reaction of coenzyme NAD^+ - to describe the catabolism of macromolecules, aerobic and anaerobic respiration and fermentation process features	- identify parts of enzymes and write properties of the enzyme - indicate which part of the enzyme catalyzes the reaction and sketch the course of enzymatic reactions to a given substrate - sketch and explain how is the inhibition of the enzyme - expressed by equation oxidation-reduction reaction of coenzyme NAD^+
		- write the material and energy balances for the given examples of catabolism, respiration and fermentation
5. Metabolic differences between microorganisms, growth, and control the growth of microorganisms	- to classify the group of the microbial based on sources of carbon and energy, the physical and chemical requirements for growth - to describe the growth of microbial cells, and growth inhibition	- recognize mechanism of metabolic activities of microorganisms specified - sketch curve of growth of microbial cells and explain each phase of growth

FORM 2

1) Course teacher: Zvonimir Glasnovic, Associate Professor

2) Name of the course: Fundamentals of Electrotechnics

3) Study programme (undergraduate, graduate): Chemical Engineering, Applied Chemistry, Environmental Engineering

4) Status of the course: Undergraduate

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. Apply the basic principles of electrical engineering to solve basic circuits;
2. Apply the analogue electronic circuits in chemical engineering problems;
3. Apply digital electronic circuits (CPU, sensors, actuators etc.) and a digital computer to manage complex technological processes in chemical engineering;
4. Identify techniques for protection of electric shock;
5. Manipulate with electronic instrumentation.

6) Learning outcomes at the level of the study programme:

1. Analyze complex circuits;
2. Apply the methodology of Electrical and Electronics in the development of chemical engineering processes;
3. Use the systems and methods for monitoring and controlling of the technological processes;
4. Apply a systematic approach to solving problems of electrical engineering and electronics in chemical engineering.

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Basic principles of electrical engineering and electronics	- Explain the principle representation engineering systems (diagram); - Explain the concept of electric current and the effects that it causes; - Explain the concept of density of electric current; - Explain the concept of electric voltage and methods for its preparation; - Explain the concept of	- Sketch basic block diagram of electrical system; - Solve relationship between current, charge and time in battery; - Calculate load of electric conductors; - Calculate four characteristic values of resistor; - Calculate any of the required values of electrical resistor.

FORM 2

	electrical resistance; - Explain the variation of resistance with temperature; - Analyze superconductivity conditions and material.	
2. Basic DC circuits	- Interpret basic relationships in electrical circuits and connect them to the universal energy principles; - Interpret Ohm's law; - Interpret the voltage distribution in resistors (voltage drop); - Interpret current distribution on resistors; - Interpret resistors in series connection;	- Solve elementary circuit; - Analyze the current-voltage conditions in elementary circuit; - Demonstrate current-voltage characteristics in the elementary circuit; - Analyze current-voltage conditions in a series connection of resistance; - Analyze the current-voltage conditions in a parallel resistance;
	- Interpret resistors in parallel connection; - Interpret resistors in complex network;	- Analyze the current-voltage opportunities in complex circuits.
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FORM 2

1) Course teacher: Ivica Gusić

2) Name of the course: Basics of Environmental Statistics and Numerical Methods

3) Study programme (undergraduate, graduate): Undergraduate

4) Status of the course: Obligatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. Apply principles from descriptive statistics in data analysis
2. Outline basic principles from probability theory
3. Outline and apply basic knowledge about continuous and discrete random variables.
4. Apply principles and techniques of estimations and tests in making decision about population using sample.
5. Apply procedures from programme package Excel.

6) Learning outcomes at the level of the study programme:

1. Apply descriptive statistics to analyse results of measurements
2. Apply probability theory to model problems in engineering
3. Apply statistics to make decision in situations from engineering

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Elements of descriptive statistics	- distinguish between population and sample - recognize and distinguish discrete and continuous statistical data - group and present statistical data - determine various data means and measures of dispersion	-- recognize in given situations the type of statistics data and sample - group given data, determine rang, frequencies and relative frequencies, arithmetic mean, mod, median, quartiles, variance and standard deviation
2. Notion of the probability, the conditional probability, the independence	-- recognize elementary events and events - calculate probability in simple situations -recognize and apply conditional probability of an	- given an experiment, determine elementary events, describe events and calculate probability -apply independence under a suitable circumstances.

FORM 2

	event - recognize and apply independence in successive repetition of an experiment	
3. Notion of the random variable (discrete and continuous). Expectation and variance	-define random variable and its distribution -distinguish between discrete and continuous random variable -interpret probability as the area under the graph of density function -calculate probability, expectation and variance -interpret and sketch the connection with descriptive statistics	- determine the distribution of a given random variable - given the density function, determine the function of distribution, expectation and variance
4. Binomial and Poisson distribution	-define the binomial distribution - recognize the binomial distribution and apply it in modelling engineering problems - define the Poisson distribution - recognize the Poisson distribution and apply it in modelling engineering problems	-recognize in concrete situations the binomial random variable, determine its range and distribution -apply the Poisson distribution in suitable situations
5. Exponential and Normal distribution	- define the exponential distribution and recognize it in concrete situations -apply the exponential distribution in modelling engineering problems -- define the normal distribution and recognize it in concrete situations -apply the normal distribution in modelling engineering problems - interpret and apply the three-sigma rule	-write down the density function and the distribution function of the exponential variable, and present its graphs -calculate probability of a concrete exponential distribution --write down the density function of the normal distribution and present the graph -apply the normal distribution in given situations
6. Estimation of parameters. Confidence interval.	- estimate the arithmetic mean and variance of a population by arithmetic	- given a sample, estimate the arithmetic mean and variance of the population

FORM 2

	mean and variance of a sample - define confidence intervals for expectation and variance. - determine confidence intervals for expectation and variance (by using an appropriate statistical package)	-given a sample, estimate confidence intervals for expectation and variance of the population
7. Basic of hypotheses testing, t-test and F-test	- outline procedures for testing hypothesis - explain the notion of the significance level -apply t-test and F-test (by using an appropriate statistical package)	-test a given hypothesis under various alternative hypothesis and various significance levels
8. Chi-square test	- describe Chi-square test - apply Chi-square test (by using an appropriate statistical package)	-sketch the procedure of Chi-square test for various distributions
9. Least square method. Correlation coefficient	- sketch the problem of adjustment of experimental data to theoretical ones - describe and apply the least square method for linear relationship - calculate the correlation coefficient	-given a statistical data, determine regression coefficients (directly and by using an appropriate statistical package) -given a statistical data, determine and comment the correlation coefficient
10. Interpolation of functions	- sketch the problem of interpolation of the function and its solution -explain and apply the Lagrange interpolation polynomial -explain and apply the cubic spline	- given the points, determine the corresponding Lagrange polynomial (by using an appropriate statistical package) - given the points determine the corresponding cubic spline (by using an appropriate statistical package)
11. Approximation of functions (optional content)		
12. Approximate differentiation and integration.		
13. Approximate solution of equations with one unknown (optional content)	-sketch the problem of approximate solution of equations	-explain geometrically a given equation and its solutions

FORM 2

	- explain and apply the tangent method -explain and apply the iteration method	-given an equation, determine approximate solution (directly and by using an appropriate statistical package)
14. Approximate solution of system of equations with more unknowns	-sketch the problem of approximate solution of system of equations -explain and apply the Newton method	-geometrically interpret a given system of two equations - given a system of two equations, apply the Newton method
15. Approximate solution of ordinary an partial differential equations	-graph the Cauchy problem y'=f(x,y), y(x0)=y0 and its approximate solution -explain the Euler method and the Runge-Kutta method	--graph a given Cauchy problem - given a Cauchy problem, determine the solution by using the Euler method and the Runge-Kutta method

FORM 2

1) Course teacher: Dr. Tatjana Gazivoda Kraljević, assis. prof.

2) Name of the course: Organic Chemistry

3) Study programme (undergraduate, graduate): undergraduate

4) Status of the course: basic

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. Identify the functional groups in the molecules and define a class of compounds
2. Apply the IUPAC rules for naming organic compounds
3. Analyze the structure of compounds with carbon, bonding in organic molecules and structures of molecules in the space
4. Define basic types of organic reactions and explain the basic reaction mechanisms with the recognition of reactive reaction intermediates
5. Define the basic reactions and synthesis reactions involving alkanes, alkenes, alkynes, alcohols, aromatic compounds, carbonyl compounds, carboxylic acids and their derivatives
6. Distinguish the reactivity of organic compounds according to the structure and connect with the corresponding reaction mechanisms
7. Apply the basic principles of modern organic chemistry and literature or our own experimental data to solve chemical engineering problems
8. Prepare, isolate, purify and identify some representatives of organic compounds related to the fundamental knowledge of organic chemistry

6) Learning outcomes at the level of the study programme:

1. Adopt a basic knowledge of mathematics, physics, chemistry and biology
2. Perform basic laboratory procedures in physical, chemical and biochemical labs
3. Safely handle with chemicals and waste materials, their management and re-use
4. Collect, identify and interpret the information about samples or processes
5. Manage and plan the time

7) Teaching units with the corresponding learning outcomes and evaluation

FORM 2

criteria		
Teaching unit	**Learning outcomes**	**Evaluation criteria**
1. Carbon compounds and chemical bonds; Class of compounds - functional groups	- analyze the structure of carbon compounds, bonding in organic molecules and structures of molecules in space - identify the functional groups in the molecules and define a class of compounds - apply the IUPAC rules for naming organic compounds	- identify the functional groups in the molecules and define a class of compounds - identify, define and distinguish the substitution, addition, elimination and rearrangement reactions
2. Alkanes and cycloalkanes	- apply conformational analysis of alkanes and cycloalkanes	- explain the conformation of alkanes and cycloalkanes
3. Stereochemistry	- define and designate isomers - explain and apply the CIP rules to determine the absolute configuration	- determine the absolute configuration of organic compounds by using CIP rules
4. Ionic reactions	- distinguish a nucleophilic substitution reaction according to the kinetics of the reaction mechanism and stereochemistry - explain when a nucleophilic reactions are in competition with an elimination reaction	- explain SN1 and SN2 nucleophilic substitution reactions vs. elimination reactions - explain stereochemical outcome of nucleophilic substitution reaction

FORM 2

5. Alkenes and alkynes, alcohols and ethers, organometallic compounds, aromatic compounds, aldehydes and ketones, carboxylic acids and their derivatives, amines, hydrocarbons	- define the basic types of organic reactions - explain the basic reaction mechanisms and identify reactive reaction intermediates - define aromatic and nonaromatic compounds - distinguish the reactivity of organic compounds depending on the structure and connect with the appropriate reaction mechanism	- apply the IUPAC rules for naming organic compounds - determine configuration by using CIP rules - define and explain the basic types of organic reactions and their mechanisms and identify reactive intermediates reaction -analyse and apply the chemical transformations and mechanisms for alkanes, alkenes, alkynes, alkyl halides, alcohols, aromatic and carbonyl compounds -prepare, isolate, purify and identify some representatives of organic compounds

FORM 2

1) Course teacher: Krešimir Košutić (Full Professor)

2) Name of the course: Physical Chemistry

3) Study programme (undergraduate, graduate): The undergraduate study of Environmental engineering

4) Status of the course: mandatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. Describe and explain the basic laws of physical chemistry related to gases, thermodynamics, phase equilibria, chemical balance, surface phenomena, electrochemical equilibrium and chemical kinetics
2. To apply knowledge of mathematics and derive equation (which clearly describe the physical phenomenon under consideration)
3. Prepare and make laboratory experiments
4. Analyze and interpret the results of experiments
5. Prepare laboratory reports

6) Learning outcomes at the level of the study programme:

1. basics of mathematics, physics, chemistry and biology
2. basic laboratory skills and working standards in physical, chemical and biochemical labs
3. time planning and management
4. collection, identification and interpreting of the information about samples or processes
5. methodology of theoretical interpretation of experimental results
6. monitoring and recording of environmental pollution by measurement of physical and chemical parameters and their systematic recording and documenting
7. analysis, synthesis, optimization and modelling of the comprehensive technologies which generate minimum waste and apply close production cycle strategy

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1.The properties of gasses	- Describe the gas laws and display them in the PVT diagram - Implement the equation of state of an ideal gas based on	Analyze and interpret p-V-T diagrams Demonstrate the skill of mathematical computation parameters in equations of

FORM 2

	thermodynamic and kinetic-molecular approach - Derive the van der Waals equation	state - Explain the difference between ideal and real gases
2.-5. Thermochemistry and thermodynamics	Describe the first, second and third law of thermodynamics and thermochemical laws (Hess' law, Kirchhoff 's Law) -Distingvish and define the heat capacity at constant pressure and constant volume - Distinguish and define the the state function of internal energy, enthalpy, entropy and Gibbs energy - Describe the spontaneity and reversibility of process - Implement the Gibbs energy dependence on pressure and temperature - Prepare and make a laboratory experiment: Calorimetry: Determination of the heat of reaction - Calculating process measurement data and interpret the results of the experiment and write a lab report	-Explain the meaning of basic thermodynamic concepts and principles - Demonstrate skill application of thermodynamic and thermal laws and available thermodynamic data when calculating the change of internal energy, enthalpy, entropy and Gibbs energy - Interpret the steady state isolated system and closed system - Derive Gibbs energy dependence on pressure and temperature
6.-7. Phase equilibria	Describe the phase equilibrium in one-component, binary and ternary systems by phase diagrams and equations - Derive Clapeyron and Clausius Clapeyron equation, Rauoltov law; Henry's law, Nernst distribution law and van't Hoff equation for osmotic pressure - Prepare and make a laboratory experiment: boiling point diagram and Nernst distribution law - Calculate and interpret	Analyze and interpret the phase diagram for simple, one-component systems -Demonstrate skill computation and application of Clapeyron and Clausius-Clapeyron equation and Augustus formula - Demonstrate skill graphic data processing -Analyze and interpret a balance liquid-vapor distillation process and the two-component system through diagrams boiling - An experimental determine

FORM 2

	eksperimental data and write lab report	the boiling diagram and define system (Zeotropic / azeotropic) - define conditions of phase equilibria, explain and interpret mathematical derivation Clapeyron and Clausius Clapeyron equation, Rauolt's law; Henry's law, Nernst' law and van't Hoff equation for osmotic pressure
8. Chemical equilibrium	-Describe the chemical equilibrium in the conditions of constant pressure and temperature using the Gibbs energy, derive thermodynamic equilibrium constant - Describe the response of equilibria to temperature and pressure - Derive van't Hoff reaction isobars - Describe the homogeneous and heterogeneous chemical equilibria	Compute equilibrium constant in the examples of homogeneous and heterogeneous equilibrium - Analyze and interpret the Haber Bosch synthesis of ammonia, optimize process parameters of pressure and temperature
9. Surface phenomena: surface tension and adsorption	Describe the phenomena at the interface: solid-gas, solid-liquid and liquid-gas - Define the surface tension and derivem Gibbs adsorption isotherm - Describe and distinguish the surface-active and non-active substances -describe surface films - Define the phenomenon of adsorption and factors affecting the adsorption and adsorption equilibrium, identify the types of adsorption isotherms - Derive Langmuir isotherm - Prepare and make a laboratory experiment: adsorption	-Explain importance of surfactants and their application in practice - Recognize the importance of experimental conditions determining the adsorption isotherm, - Freundlich isotherm parameters interpret - Demonstrate skill computation and application Frundlichove, Langmurove and BET isotherms

FORM 2

	- Calculate and interpret measurement data and write the Freundlich adsorption isotherm and write a lab report	
10.-12. Electrochemistry: the conductivities of electrolyte solution, equilibrium electrochemistry	- Describe conductivity of electrolytes and distinguish strong from weak electrolyte, define I and II. Kohlraush' law -Derive an Ostwald's law - Define the concept of activity - Explain the Debye-Hückel theory of strong electrolytes Describe the equilibrium of electrode-solution -Derive the thermodynamic expression for the electrode potential -Define the electromotive force Nernst equation Prepare and make a laboratory exercise of electrolyte conductivity and EMS - Calculate measurement data and interpret the results of the experiment, and write a lab report	- An experimental determine the conductivity of strong and weak electrolytes - An experimental determine electrode potential and electromotive force (EMF) - Demonstrate skill calculating molar conductivity, degree of dissociation, activity coefficients, electrode potentials - Explain the relationship between EMS and the Gibbs energy and utility measurements EMS - Recognize the importance of cell production as the most efficient energy converters
13.-15. The chemical kinetics	Define the rates of a chemical reaction, and the factors that affect the rate of chemical reactions - Define the reaction order - Describe the methods for determining the reaction rate constants and reaction order - List reactions to the kinetic mechanism of the elementary and complex - describe the kinetics of reverse,parallel, and consecutive reactions - describe the temperature dependence of reaction rate	Explain the importance of chemical kinetics, the rate of chemical reactions and impact to the rate of the reaction using catalysts, inhibitors and retardants - Experimentally determine rate constants, reaction order and interpret the influence of temperature on the rate constant - Demonstrate skill computing - give example: Chapman model of kinetic mechanism of depletion of ozone in the

FORM 2

	(Arrhenius equation) - Describe the theory of transition state (activated complex) - Define the basic concepts of catalytic reaction Prepare and make a laboratory experiment: Decomposition of H2O2 - Calculate measurement data and interpret the results of the experiment, and write a lab report	stratosphere

FORM 2

1) Course teacher: Assis. Prof. Krunoslav Žižek, PhD

2) Name of the course: Transport Phenomena

3) Study programme: Undergraduate study programme Environmental Engineering

4) Status of the course: Required

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. Get acquainted with transport phenomena (momentum, heat and mass transfer), and with conservation laws they involve.
2. To define the effects of flow regime (that is hydrodynamic conditions) on heat and mass transfer.
3. To understand fundamental laws and equations at macro-scale of the phenomenon, and to apply them (regarding the mechanism) for estimation of heat and mass properties in considered hydrodynamic system.
4. To utilize the concept of transport phenomena analogy (momentum and heat transfer, momentum and mass transfer) for quantifying transport coefficients.

6) Learning outcomes at the level of the study programme:

1. Gaining of fundamental knowledges regarding core engineering courses.

2. To adopt chemical engineering methodology.

3. Gaining of skills for a lab work and for gathering and interpretation of environmental data.

4. Time planning and management.

5. To evolve the aptitude for individual and team work.

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	**Learning outcomes**	**Evaluation criteria**
1. Introduction to transport phenomena fundamentals	- to define terms necessary for understanding and description of processes with immanent transport phenomena (momentum, heat and mass transfer)	- distinguish the mechanisms of transport phenomena - define basic equations that are descriptors for processes with occurring transport phenomena - differ Newton and non-Newton fluids and summarize model equations that are used as their descriptors
2. Momentum transfer	- to memorize and to adopt conservation laws regarding	- use conservation laws (regarding fluid flow phenomena) for estimation

FORM 2

	fluid flow phenomena - to define the structure and birth of hydrodynamic boundary layer - to understand fundamentals of fluid flow phenomena - to recognize characteristic cases (processes) regarding momentum transfer and to apply congruent equations	of pump power required for liquid transport in a pipeline with a complex design - define the effect of flow regime (that is hydrodynamic conditions) on the structure of boundary layer - determine flow velocity in a pipe (mainly circular tube), sketch velocity distribution and relate maximum and mean (average) flow velocity for both laminar and turbulent flow in pipes
3. Heat transfer	- to define and to differ mechanisms of heat transport /heat transfer modes (heat conduction, convection, radiation) - to use equations for stationary and non-stationary heat conduction - to define the effect of hydrodynamic conditions on heat transfer by forced convection in pipes - to summarize the concept and basic laws regarding heat transport by radiation	- explain the criterion for detection and differing mechanisms for heat transport - define driving force of the process, the area of heat exchange, the overall heat transfer coefficient and calculate heat flow regarding various process conditions (flow regimes) - detect the effect of hydrodynamic conditions on heat transfer - reveal the concept for defining of various dimensionless numbers and to adopt their meaning - explain Planck, Stefan-Boltzmann and Kirchhoff radiation laws
4. Mass transfer	- to memorize and to differ mechanisms of mass transport - to use equations for estimation of intrinsic property of a system for each	- outline usage of Fick's law of diffusion - calculate mass flow regarding various process conditions - detect the effect of

FORM 2

	mass transfer mechanism - to know methods for estimation of heat and mass transfer coefficient	hydrodynamic conditions on mass transport - apply appropriate correlations and differential equations to estimate the mass transfer coefficient
5. Analogies of transport phenomena (momentum, heat and mass transfer)	- to solve practical problems of detecting relevant heat and mass transport properties by using concept of Reynolds and Chilton-Colburn analogy	- by knowing the momentum transport (fluid flow phenomena) property estimate the heat and mass transfer properties (coefficients)

FORM 2

1) Course teacher: Prof. Felicita Briški, PhD.

2) Name of the course: Environmental Protection

3) Study programme - undergraduate: Environmental Engineering

4) Status of the course: mandatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. to explain the composition and basic processes in the atmosphere, hydrosphere and lithosphere, and the impact of different types of pollution on the abiotic and biotic resources
2. to apply the principles of mathematics, physics, chemistry and microbiology in monitoring and analyzing the distribution of contaminants in water, soil and air
3. to explain and compare the systems of water treatment and wastewater treatment, explain the systems for processing solid waste and treatment of harmful gases
4. to outline a simple scheme of the process of processing pollutants
5. to apply laws and regulations related to environmental protection

6) Learning outcomes at the level of the study programme:

1. to identify the problems in the environment (water, soil, air) and apply theoretical knowledge to solve problems
2. to apply methodology of chemical engineering and environmental engineering in solving problems in the environment and in industry
3. to choose simple processes and process equipment for treatment the pollutants in waste streams
4. to assess how designed process affects on the global environment
5. to analyze the impact of new technologies, environmental concerns and public opinion on the legislation

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Ecosystems, flow of substances in the environment, population and demographic changes	- to describe the flow of matter and energy in the biomes - to explain the transport and transformation of substances in the environment - to analyze the rate of	- illustrate the flow of matter and energy in the biomes and state the energy efficiency - describe and sketch the cycles of substances in the environment - solve the growth rate and

FORM 2

	growth of the human population in different parts of the world	the doubling time of the human population applying differential equation
2. Classification of water, pollution of water sources, waste water and waste water treatment	- to distinguish the characteristics of rivers, lakes and oceans - to select and apply appropriate process to remove contaminants from groundwater - to analyze the chemical composition of the waste water - to select and apply appropriate process and process equipment for waste water treatment	- explain the importance of the thermocline and label it on the diagram of vertical profile of the water column - describe mechanisms of filtration and adsorption, and write mathematical expressions that describe the adsorption isotherm - explain the composition of waste water and purpose of waste water treatment, and point out the consequences of discharge of untreated water in the receivers - outline the process of wastewater treatment and set up the mass balance
3. The soil as a natural phenomenon, the use of soil and soil pollution, solid waste management	- to describe the formation of soil and identify types of soils - to analyze the impact of over-use of pesticides - to explain and differentiate the procedures for solid waste management	- explain factors which influence the formation of soil - summarize the mechanisms of distribution of pesticides in the environment, and procedure of their removal from the environment - select the appropriate disposal procedure for a given type of solid waste
4. The atmosphere and the movement of air masses, the sources of air pollution and the removal of harmful gases	- to describe the layers of the atmosphere and explain the movement of air masses - to identify the sources of pollution in the atmosphere, and specify process equipment for treatment of flue gas	- indicate the chemical composition of the atmosphere, and sketch the layers of atmosphere - explain the difference between stationary and mobile sources of pollution, and select the procedures to prevent emissions
5. Noise, light pollution, thermal pollution and	- to indicate the sources and methods for noise	- calculate the overall noise level for a given group of

FORM 2

radioactive contamination	measurement, and explain the implementation of noise protection - to identify sources of light pollution and choose the proper illumination - to analyze the sources of pollution of thermal power plants, and select the treatment processes for removal of pollution - to describe the application of radioactive substances, and differentiate types of radioactive waste - to explain the methods of disposal of radioactive waste	machines, and select equipment for noise reduction - describe the impact of light pollution on the environment, and define the type of illumination for a given space - describe the impact of untreated pollutants from power plants on the environment, and apply proper process for removal of thermal pollution - list the sources of radio-active radiation, sketch and describe the types of radiation and their impact on environment - select a disposal procedure for a given radioactive waste

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FORM 2

1) Course teacher: **Assoc. Prof. Jasna Prlić Kardum, PhD**
Assoc. Prof. Gordana Matijašić, PhD

2) Name of the course: Fluid Mechanics

3) Study programme (undergraduate, graduate): Undergraduate, Environmental Engineering

4) Status of the course: Required

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. The ability to identify and describe rheological behavior of fluids.
2. Apply fundamental knowledge of fluid statics and dynamics for compressible and incompressible fluids.
3. The ability to choose and apply adequate equipment for fluid transport.
4. Apply fundamental principles of fluid mechanics to solve problem s in two-phase flow regime.
5. Ability to analyze open channel flows

6) Learning outcomes at the level of the study programme:

1. The ability to apply chemical engineering methodology.
2. The ability to apply basics of fundamental engineering knowledge.
3. The ability to apply methodology of theoretical interpretation of experimental results.
4. The ability for critical analysis and solving of environmental problems.
5. The ability to work both independently and in multidisciplinary teams.

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Rheological behavior of fluids	- Define the basic terms of fluid mechanics - Identify rheological behavior of fluid	- Define fluid concepts, continuum hypothesis and properties of fluid - Name the forces in fluids - Sketch rheological diagrams - Identify rheological equations depending on rheological behavior

FORM 2

2. Fluid statics	- Define the basic terms of fluid statics - Describe Euler equation - Understand the manometer principle of operations	- Describe hydrostatic pressure -List and describe the mode of hydrostatic manometers - Calculate a liquid level in a tank
3. Dynamics of incompressible fluids	- Understand the principles of continuity momentum and energy as applied to fluid motions - Describe flow equations - Understand laws for non-newtonian fluids	- Recognize and describe these principles written in form of mathematical equations - Calculate velocity distribution of Couette flow - Define meaning of Navier-Stocks equation - Apply Navier-Stocks equation to analyze problems - Define flow, velocity distribution and pressure drop for non-newtonian fluid flow
4. Fluid transport	- Define fluid motions through narrow orifices - List and classify types of pumps - Compute the branched pipeline	- Define cavitation conditions - Derive equation and calculate the required time for tank discharge - Outline characteristics of pumps - Explain selection criteria and pump design - Calculate the pressure drop and the pump power for fluid transport through the branched pipeline
5. Dynamics of compressible flow	- Describe characteristics of compressible fluids - Explain isothermal flow of ideal gas in horizontal pipe	- Apply conservation laws for compressible fluids - Evaluate head loss for the isothermal fluid flow
6. Dynamics of heterogeneous system	- Analyze characteristics of two-phase flow	- Predict and describe flow regimes in gas-liquid system

FORM 2

	- Categorize homogenous and heterogeneous systems	- Evaluate pressure drop for two-phase flow - Describe hydraulic transport of heterogeneous systems - Define factors affecting rheological behavior - Explain pneumatic transport
7. Open channel flow	- Describe steady state flow in open channel - Define types of flow in open channel - Understand the phenomena of hydraulic jump	- Distinguish uniform and non-uniform flow - Discuss hydrodynamic laws for the flow through granular layer - Define conditions and critical velocity for hydraulic jump to occur

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FORM 2

1) Course teacher: Associate Prof. Dragana Mutavdžić Pavlović, Associate Prof. Stjepan Milardović, and Assistant Prof. Tatjana Gazivoda Kraljević

2) Name of the course: Environmental Chemistry

3) Study programme (undergraduate, graduate): Undergraduate, 2nd year

4) Status of the course: required

5) Expected learning outcomes at the level of the course (4-10 learning outcomes	**6) Learning outcomes at the level of the study programme:**
1. Explain the way for metal chelates forming by means of natural existed ligands (humic and fulvic acid) and with artificial (pollutions) ligands as polyphosphates, EDTA, NTA, citrates etc. 2. Calculate ion metal concentration in equilibrium with metal chelates complexes at different pH. 3. Calculate ion metal concentration in solutions containing hydroxide, sulphides and carbonates at different pH. 4. Use the Purbeix diagram in design of chemical processes for different water treatments. 5. Explain metals cation measurements by ion selective electrodes and by stripping voltammetry. 6. Explain the basic processes in the biosphere and the components interaction and photochemical processes in the environment. 7. Apply principles of "green" chemistry in basic organic reactions and modern organic synthesis. 8. Define access to environmental analysis. 9. Recognize the sample from the environment (water, soil, air) and choose the method of analysis depending on the investigated pollutants. 10. Distinguish approach to the analysis of	1. Monitor and observe environmental pollution by measuring chemical quantities and their systematic recording and documentation 2. Collect, determine and interpret information about the sample 3. Solve problems in the field of environmental protection 4. Apply the methodology of analytical procedure 5. Manage and plan the time

FORM 2

trace pollutants in the environment (soil, water, air) from the analysis of macro ingredients.	

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Behavier of metal ions in water. Precipitation of metal and formation of metal chelating complex	It is expected that the student will be able to: -explain the function of chelates ligands in water metal circulating processes	- Students answer the question based on application of theoretical principles Students solve the worked examples applying theoretical knowledge
2. Precipitation and solubility of metal hydrates, sulphides and carbonates	It is expected that the student will be able to : -:calculate metal ion concentration in solution of low soluble hydroxides, sulphides or carbonates	Students answer the question based on application of theoretical principles Students solve the worked examples applying theoretical knowledge -
3. Electrochemical measurements by ion selective electrodes	It is expected that the student will be able to: -use Nernst equation for description the ion selective electrode response	Students answer the question based on application of theoretical principles Students solve the worked examples applying theoretical knowledge
4. Construction of the Purbeix diagram for Fe-O-H_2O system	It is expected that the student will be able to: -use the Purbeix diagram and select the method for proper water treatments	Students answer the question based on application of theoretical principles Students solve the worked examples applying theoretical knowledge
5. The interaction of the environment components; The cycle of basic processes in the biosphere; The water cycle; The carbon cycle; The nitrogen cycle; Organic pollutants in soil; Organic pollutants in water;	- explain the interactions of the environment components and cycle processes in the biosphere - classify and identify organic pollutants in soil and water	- distinguish organic pollutant in soil, water and atmosphere

FORM 2

Pesticides.		
6. Atmospheric chemistry. Organic pollutants in air; photochemical processes in atmosphere; Photodegradation of organic pollutants; Photochemical smog and a threat to the global atmosphere; Damage to the ozone layer.	- identify the organic pollutants on the basis of the structure - explain the photochemical processes in the atmosphere and influence the photochemical smog on the ozone layer	- apply knowledge of the basic photochemistry to understanding atmospheric chemistry - propose photodegradation pathways for a given organic pollutants in water
7. Environmental biochemistry; The biochemical mechanisms of toxicity; Toxicology of organic compounds; Introduction to ecotoxicology.	- explain the biochemical mechanisms of organic compounds toxicity	- recognize the potential formation of toxic substances from various biomolecules
8. "Green" chemistry in the application of basic organic reactions: Nitration; Halogenation; Alkylation; Oxidation; Sulphonation	- distinguish classical methods of organic synthesis and "green" methods - explain and distinguish modern "green" organic reactions	- propose alternative "green" methods for the synthesis of a given compounds - carry out the synthesis of organic compounds by "green" reaction
9. Modern organic synthesis - a "green" approach: Reactions without solvent; Micowave reactions; Tandem and domino reactions; Application of "green" solvents.	- apply the principles of "green" chemistry in elementary organic reactions and modern organic synthesis	- apply microwave assisted reactions, tandem and domino reactions for the synthesis of a given compounds - analyze the obtained compounds and interpret the results in writing form
10. Access to chemical analysis of environmental samples	- define the analytical process - distinguish the application of classical methods of chemical analysis from instrumental methods in the analysis of environmental samples - distinguish the sampling methods depending on the environmental sample (water, soil and air)	- recognize the importance of each step of the analytical process, - know the basic principle of individual methods of analysis

FORM 2

11. Environmental samples (water, soil, air)	- define indicators of water quality - explain water pollution by heavy metals and other inorganic compounds - write the reactions of metals with organic compounds, - explain the mechanisms of mobility and binding of contaminants in the soil, - estimate the indicators of air pollution	- distinguish approach to chemical analysis of the soil, water or air, - ability to independently access to chemical analysis of environmental samples, - evaluate, compare, select, recommend and conclude what is the best analytical method for a given real problem, - numerically solve problems on the basis of the measurement parameters
12. Laboratory exercises	- apply the principles of good laboratory practice, - properly collect and process measurement data, - write the appropriate laboratory report	- carry out an environmental sample analysis, - numerically express and process the results on the basis of the measurements data, - show independence in laboratory work, - write the experimental data and making the laboratory reports.

FORM 2

1) Course teacher: Associate prof. Ana Vrsalović Presečki, PhD

2) Name of the course: Mass and energy balance

3) Study programme (undergraduate, graduate): undergraduate

4) Status of the course: mandatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. apply the principles of mass and energy conservation in the physical and chemical processes
2. define the process space , system boundaries , and input and output of the process
3. distinguish stationary and non-stationary as well the open and closed processes
4. set the energy and mass balance in the model systems
5. outline a simple scheme of the process of chemical and related industries

6) Learning outcomes at the level of the study programme:

1. analyze and optimize the processes of chemical and related industries
2. apply the methodology of chemical engineering in the process development
3. manage and plan the processes
4. apply mathematical methods, models and techniques in solving case studies

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Mass balance of the physical processes	- apply the principle of mass conservation on physical processes - define the process space, system boundaries, and input and output of the process - set the mass balance of the task examples - outline a simple scheme of the process of chemical and related industries	- outline the process scheme, and identify the input and output flows of process - determine the basis for calculation - apply the law of mass conservation of and set the mass balances for the process - solve the system of independent linear equations
2. Mass balance of the	- apply the principle of mass	- outline the process scheme,

FORM 2

chemical processes	conservation on physical and chemical processes - define the process space, system boundaries, and input and output of the process - set the mass balance of the task examples - outline a simple scheme of the process of chemical and related industries	and identify the input and output flows of process - determine the basis for calculation - apply the law of mass conservation of and set the mass balances for the process - solve the system of independent linear equations
3. Mass balance of the processes performed in the multiple units with of without recycle	- apply the principle of mass conservation on physical and chemical processes - define the process space, system boundaries, and input and output of the process - set the mass balance of the task examples - outline a simple scheme of the process of chemical and related industries	- outline the process scheme, and identify the input and output flows of process - determine the basis for calculation - apply the law of mass conservation of and set the mass balances for the process - solve the system of independent linear equations
4. Energy balance of the physical processes	- apply the principle of mass and energy conservation on physical processes - define the process space, system boundaries, and input and output of the process - define the initial and final state of the system - learn to use the thermodynamical tables in order to find the data necessary to calculate the energy balance - set the energy balance of the task examples - outline a simple scheme of the process of chemical and related industries	- outline the process scheme, and identify the input and output flows of process - determine the referent state - find literature data necessary to calculate the energy balance according to the initial and final state of the system and referent state - apply the law of energy conservation of and set the energy balances for the process - solve the system of independent linear equations

FORM 2

5. Energy balance of the chemical processes	- apply the principle of energy conservation on physical and chemical processes - define the process space, system boundaries, and input and output of the process - define the initial and final state of the system - learn to use the thermodynamical tables in order to find the data necessary to calculate the energy balance - set the energy balance of the task examples - outline a simple scheme of the process of chemical and related industries	- outline the process scheme, and identify the input and output flows of process - determine the referent state - find literature data necessary to calculate the energy balance according to the initial and final state of the system and referent state - apply the law of energy conservation of and set the energy balances for the process - solve the system of independent linear equations

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FORM 2

1) Course teacher: Sandra Babić, Tomislav Bolanča, Sanja Papić

2) Name of the course: Modern Analytical Techniques in Analysis of Environment

3) Study programme (undergraduate, graduate): undergraduate study – Ecoengineering

4) Status of the course: obligatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

6. To explain sampling methods for monitoring people and environment exposure to pollutants, risk assessment, and environment protection intentions.
7. To explain and apply sample preparation methods for chemical analysis.
8. To apply spectrometric analytical methods in ecoengineering.
9. To apply separation analytical methods in ecoengineering.
10. To apply principles of validation of analytical procedure.
11. To recognize types of pollution and characteristics of wastewater from chemical and related industries.
12. To select and apply characterization elements for analysis of industrial wastewater and water environment.
13. To apply modern analytical techniques for determination of selected ecological indicators in protection of water environment.

6) Learning outcomes at the level of the study programme:

6. To apply basic knowledge of chemistry.
7. To develop ability of technologies' analyses.
8. To develop basic laboratory skins and define working rules in chemical laboratories
9. To track and monitor environment pollutions by measuring chemical indicators.
10. To demonstrate methodology of analytical process.

7) Teaching units with the corresponding learning outcomes and evaluation criteria

FORM 2

Teaching unit	Learning outcomes	Evaluation criteria
4. Sampling and preparation of sample for analysis.	- To explain sampling methods for monitoring people and environment exposure to pollutants, risk assessment, and environment protection intentions. - To explain and apply sample preparation methods for chemical analysis. - To explain and apply separation methods.	- To define unit, cumulative, laboratory and examine sample. - To explain methods of subsampling. - To select sampling method and explain his suitability in relation with the desired information. - To specify objectives of preparing sample for chemical analysis. - To demonstrate knowledge of solvent extraction (extraction liquid-liquid and solid liquid). - To demonstrate knowledge of solid phase extraction - To select optimal method for preparation of sample for chemical analysis.
5. Instrumental analysis and data treatment	- To apply spectrometric analytical methods in ecoengineering. - To apply separation analytical methods in ecoengineering. - To apply principles of validation of analytical procedure.	- To demonstrate knowledge of principles of molecular spectroscopy, to define advantages and disadvantages as well as the application in ecoengineering. - To demonstrate knowledge of principles of atomic spectroscopy, to define advantages and disadvantages as well as the application in ecoengineering.

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		- To demonstrate knowledge of principles of separation analytical methods, to define advantages and disadvantages as well as the application in ecoengineering. - To select critically an optimal instrumental method for analysis.
6. Analytical methods of determination of ecological indicators	- To recognize types of pollution and characteristics of wastewater from chemical and related industries. - To select and apply characterization elements for analysis of industrial wastewater and water environment. - To apply modern analytical techniques for determination of selected ecological indicators in protection of water environment	- To demonstrate knowledge about diverse types of pollutants as well as characteristics of wastewater from chemical and related industries that can pollute water environment. - To demonstrate knowledge of elements of water characterization (industrial wastewater/water environment). - To demonstrate knowledge of principles of total organic carbon analysis and its application in ecoengineering. - To demonstrate knowledge of principles of chemical consumption of oxigen and its application in ecoengineering. - To demonstrate knowledge of principles of turbidimetry and its application in ecoengineering.

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		- To demonstrate knowledge of principles of toxicity methods and its application in environment protection.

FORM 2

English language (basic course)
COURSE AIM: The acquisition of competencies such as reading, oral and written fluency in English, illustrating usage of expert engineering terminology. Generating new vocabulary by using on line dictionaries on their own to recall pronunciation and meaning. Preparation of presentations for purposes of practicing oral interpretation for future international conferences. Students are also introduced to some customs regarding the cultures of the United States and the United Kingdom.
DEVELOPMENT OF GENERAL AND SPECIFIC COMPETENCIES OF STUDENTS:
General competencies: pronunciation of expert terminology that refers to various types of engineering and technology in English.
Specific competencies: writing a CV and illustrating usage of English grammar. Orally presenting a lab report which was previously filmed and placed in their e-portfolio.
STUDENT OBLIGATIONS: students are obliged to attend classes and solve all the revision tests in their e-class. They are also obliged to enter new vocabulary in the glossary of their e-class individually. They must have their indeks or ID card when writing midterm tests or final written tests.
SIGNATURE CONDITIONS: 80 percent attendance in each semester and taking part in class by engaging in class work. They must have a Euro pass CV and filmed lab experiment in their e-portfolio.
They must have a positive grade on their midterm test 1.
LECTURES METHOD: Lectures, language exercises in class such as reading, comprehension, pair work, group work, individual group work that is to be placed in their e-portfolios, revision of grammar by individually solving the revision tests in the e-class, consultations if need be every week.
MANNER OF ASSESSMENT AND TESTING:
Written midterm tests (60 percent or more on both midterm tests excludes the need for final written and oral exam)
Final written test (60 percent or more for passing grade) and oral exam (oral presentation of lab experiment in their e-portfolio)
QUALITY CONTRUL AND SUCCESS OF COURSE: Anonymous student survey
METHOD PREREQUISITES:
Access to a computer and knowledge of e-class password and e-portfolio password in Moodle and Merlin programs.
i) COURSE LEARNING OUTCOMES:
1 students will generate basic concepts of engineering terminology in English
2 students will demonstrate individual discovering of pronunciation of new vocabulary and the
definition of the newly acquired expert terms
3 students will demonstrate ability to use the e-portfolio for recording personal improvement
4 students will demonstrate recalling grammar by solving the revision tests in their e-class

j) PROGRAM LEARNING OUTCOMES:

1 students will recall expert terminology used in the various fields of engineering
2 students will generate an advanced usage of grammar in the English language

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3 students will recall how to write a CV, cover letter and reply to an job ad in the paper
4 students will use the Merlin and Moodle computer programs to do individual or group work
in their e-class and e-portfolio.

FORM 2

English language (advanced course)
COURSE AIM: Acquiring competencies such as reading, oral and written fluency in English in the field of technology. Individual analysis of new vocabulary by using the on line dictionaries to discover the pronunciation and definition. Individual examination of revision tests in the e-class. Preparation for making oral presentations in English. Students also learn about the customs and cultures of the United States and the United Kingdom.
DEVELOPEMENT OF GENERAL AND SPECIFIC COMPETENCIES OF STUDENTS:
General competencies: pronunciation of expert terminology related to the field of technology in English. Understanding of expert terminology and usage both in written and oral form.

Specific competencies: oral presentation of lab report and entering new vocabulary in the glossary of the e-class. Recalling grammar by revision of tests in the e-class. Practising usage and pronunciation of new vocabulary.

STUDENT OBLIGATIONS AND MANNER OF FULFILMENT: Students are expected to attend at least 80 percent of all classes and are obliged to put their CV and group presentation in their e-portfolio. They are also expected to solve all revision tests in the e-class individually. They have to bring their indeks or ID cards during midterm and final tests.
SIGNATURE CONDITIONS: In order to get a signature at the end of each semester they must attend at least 80 percent of all classes and take part in language exercises, orally present their group work of the lab experiment conducted at the University and placed in their e-portfolio.
They must pass midterm tests 1 and 2.
LECTURE METHOD: Lectures and language exercises such as reading out loud, comprehension, pair work, group work and consultations when necessary.
ASSESSMENT METHOD AND EXAMINATION:
Written midterm tests (60 percent or more on both midterm tests excuses the student from having to take the final written and oral tests)
Final written test (at least 60 percent required to pass) and oral exam (presentation of lab experiment filmed as part of group work and put in their e-portfolio)
QUALITY CONTROL AND SUCCESS OF COURSE: Anonymous student survey
METHOD PREREQUISITES:
Access to a computer and demonstration of using the e-portfolio and e-class programs via passwords in the Merlin and Moodle programs intended for students of Zagreb University.

COURSE LEARNING OUTCOMES:
1 students will be able to use the basic terminology in the field of technology in English.
2 students will explain new vocabulary and arrange it in the e-class glossary individually
3 students will use the e-portfolio to record personal development
4 students will examine the revision tests in the e-class and recognise the grammar and be able
to use it in both written and oral communication

PROGRAM LEARNING OUTCOMES:
1 students will understand expert terminology used in the contemporary fields of technology
2 students will review and use English grammar at an advanced level

FORM 2

3 students will conclude how to present a lab report both orally and in writing
4 students will demonstrate usage of the e-class and e-portfolio in the Merlin and Moodle
programs intended for students of Zagreb University

1) Course teacher:	**Assoc. Prof. Gordana Matijašić, PhD** **Prof. Aleksandra Sander, PhD**
2) Name of the course:	**Unit operations in environmental engineering**
3) Study programme (undergraduate, graduate):	**Environmental Engineering, Undergraduate**
4) Status of the course:	**Required**
5) Expected learning outcomes at the level of the course (4-10 learning outcomes):	**6) Learning outcomes at the level of the study programme:**
1. Explain and analyze the selected thermal separation processes. 2. Explain the utilization of energy separating agent and mass separating agent in the selected thermal separation processes. 3. Define mechanisms of mass and heat transfer in the individual separation process and the corresponding individual and overall resistances. 4. Define properties of coarse disperse phase, methods of measurement, graphical interpretation and approximation of particle size distribution. 5. To analyze mechanical separation processes. 6. To analyze mixing of homogenous and heterogeneous systems. 7. To analyze energy and kinetic aspects of the grinding process. 8. To conduct experiments in laboratory scale in order to estimate the parameters required for the process design.	1. The ability to apply basics of fundamental engineering knowledge. 2. Organizational and planning abilities necessary to perform simple experiments with available laboratory equipment and devices. 3. The ability for critical analysis and solving of environmental problems 4. The ability to apply the methodology of the theoretical interpretation of experimental results.
7) Teaching units with the corresponding learning outcomes and evaluation	

FORM 2

criteria		
Teaching unit	**Learning outcomes**	**Evaluation criteria**
1. Heat exchangers	- define criteria's for classification of heat exchangers - analyze the performance of heat exchangers	- compare different types of heat exchangers - evaluate heat flow and heat transfer area - evaluate the efficiency of heat exchangers
2. Evaporation	- describe different types of evaporators - explain methods of evaporation - solve mass and heat balances and kinetic equation for heat transfer - explain energy saving methods	- schematically illustrate evaporator and define inlet and outlet process streams - know how to use tables and diagrams necessary for the calculations - calculate heat consumption and heat transfer area o fan evaporator - distinguish different types of evaporators
3. Separation with the addition or development of new phase	- explain separation by means of absorption, distillation and solvent extraction - explain phase equilibriums - define balance (mass and heat) and kinetic equations for selected separation processes - explain graphical and numerical methods for design of column separators - describe equipment and working principles of equipment	- schematically illustrate separation process with inlet and outlet process streams and the corresponding balance equations - based on the phase equilibrium and physicochemical properties of the components select solvent for extraction and absorption - illustrate process in the corresponding equilibrium diagrams - use graphical and numerical methods for dimensioning column separators (NTU, HTU, H, D) - distinguish columns with different types of internals

FORM 2

		(plates, packing)
4. Separation processes with the solid phase	- define methods of the selected separation processes - explain separation by means of crystallization and drying - define mass and heat balances - describe equipment and its working principles - explain energy saving methods for drying	- explain methods of crystallization (solution, melt, gas) - based on the solubility diagram select method of crystallization from solution - calculate mass of crystals and heat consumption of the crystallizer (mass and heat balances) - use humidity charts when solving numerical examples related to drying - illustrate and explain the drying curves
5. Characterization of coarse disperse phase.	- analyze the properties of coarse disperse phase - recognize the methods of characterization of coarse disperse phase	- distinguish disperse system, disperse phase and disperse medium - define dispersity state and mixedness - explain particle shape and meaning of equivalent diameters - sketch the graphical representation of particle size distribution
6. Mechanical separation processes	- define separation efficiency - describe sedimentation and filtration - identify inlet and outlet variables	- distinguish total and grade efficiency - explain separation efficiency through characteristic values - explain basics of gravitational and centrifugal sedimentation - explain the basics of deep-bed filtration, cake filtration and centrifugal filtration - apply theoretical

FORM 2

		knowledge about cake filtration in practical measurement
6. Mixing of fluids, suspensions and powders	- define degree of mixing in homogenous and heterogeneous systems - define primary variables that determine the mixing conditions - analyze dynamic process response	- distinguish hydrodynamic regime in liquid-liquid and solid-liquid mixing - explain possible suspension states and suspending regimes - define powder types, mixture types and mixture quality - explain particle segregation and mechanisms of segregation
7. Comminution	- analyze energy and kinetic aspects of the grinding process	- explain models for estimation of energy consumption in comminution - describe kinetics of particle size reduction - apply theoretical knowledge in practical measurement - name the types of equipment

FORM 2

1) Course teacher: prof. dr. sc. Veljko Filipan

2) Name of the course: ENGINEERING THERMODYNAMICS

3) Study programme (undergraduate, graduate): undergraduate

4) Status of the course: mandatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. apply basic laws of thermodynamics for thermodynamic calculations of processes with ideal and real working media

2. apply graphical representation in defining and analysis of thermodynamic processes

3. use tables and diagrams with thermodynamic properties of some particular real working media applied in real processes and devices

4. define energy indicators of thermodynamic processes and devices working in heating and cooling modes

5. analyse environmental impact of thermodynamic processes and transformations

6) Learning outcomes at the level of the study programme:

1. analysis, synthesis, optimization and modelling of the comprehensive technologies which generate minimum waste and apply close production cycle strategy,

2. basics of fundamental engineering knowledge

3. critical analysis of environmental problems

4. creation of a database of engineering knowledge as a starting point for the improvement of technologies with minimum impact on the environment

5. learning skills and competences required for further vocational training

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7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. basic thermodynamic laws and thermodynamic quantities	- understand basic terms and definitions in engineering thermodynamics - differentiate thermodynamic quantities such as enthalpy, entropy, heat, energy and work - connect the 1st and the 2nd law of thermodynamic - differentiate thermodynamic	- define basic thermodynamic state quantities and thermal quantities - explain analytical expressions of thermodynamic laws - calculate mechanical work due to volume changes and technical work - define basic cyclic

FORM 2

	processes according to the direction of the process	processes
2. processes with ideal working media	- define basic processes with ideal gasses; represent them in thermodynamic diagrams - define processes of compression and expansion; differentiate real and ideal ones - calculate reversible and irreversible thermodynamic processes with ideal gasses - know achievable cyclic processes	- reproduce and explain the equation of state for ideal and real working media - sketch p,v T,s and h,s diagrams of basic processes with ideal gasses - generate diagrams of achievable cyclic processes - calculate thermodynamic properties and energy performance of particular cyclic processes
3. processes with real working media	- explain thermal properties and changes in real working media	- sketch and explain p,v T,s and h,s diagrams of basic thermodynamic processes with real working media
	- use charts and tables with real working media properties for the calculation of basic processes	- use h,d diagram for defining real processes with wet air

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FORM 2

1) Course teacher: Prof. Marija Vuković Domanovac, PhD

2) Name of the course: Air, Water and Soil Management

3) Study programme (undergraduate, graduate): undergraduate

4) Status of the course: obligatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):	**6) Learning outcomes at the level of the study programme:**
1. to recognize the causes and sources of pollution, air, water, soil and noise pollution 2. to define measurable indicators to assess the state of resources in the environment 3. to predict the possibility of air, water and soil pollution by taking preventive concrete measures to prevent or reduce adverse impacts 4. to distinguish measures for the pollution prevention and remediation of caused pollution 5. to integrate legislation in the field of protection and conservation of the natural components of the environment into the environmental engineering planning	1. to link the basic knowledge in the environmental engineering planning and analysis of the impact of pollution on the environment 2. to apply eco-engineering approach in the analysis of indicators of the state of the environment 3. to develop awareness and to train the students in the implementation of preventive measures to protect the environment 4. to apply new technologies aimed at reducing negative environmental impacts, and consumption of raw materials and natural resources for sustainable development 5. to operate the system of environmental protection

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	**Learning outcomes**	**Evaluation criteria**
1. Air management	- to define the sources of air pollution, sampling, measurement of pollutants and data analysis - to predict the extent and methods of organizing the protection and improvement of air quality - to integrate legislation on air quality when choosing	- distinguish primary and secondary air pollutants and methodology in data collection and analysis - interpret of the procedures for the purification of air - interpret the legislation in the field of air management

FORM 2

	protection measures	
2. Water management	- to describe the management and protection of water resources - to describe the preparation of drinking water - to solve the problem of wastewater treatment and sludge disposal with the design process - to define industrial wastewater - to integrate legislation on water quality in the processes of management, protection and water treatment	- recognize sources of pollution and measures for water protection - describe and explain the process of purifying drinking water - distinguish physical, chemical and biological processes for wastewater management - interpret the legislation in the field of water management
3. Soil management	- to define the processes in the formation of soil fertility and soil erosion - to define the production, physiological and ecological function of the soil - to indicate the use of soil - to explain the remediation of soil and groundwater - to integrate legislation in the processes of soil management	- define the factors and processes related to the soil management - apply preventive and remedial measures - use the soil as a source of raw materials, habitat, cultural heritage - illustrate the remediation of soil and groundwater - interpret the legislation in the field of soil management
4. Noise management	- to define the sources, the path of expansion and noise reception - to predict noise protection measures - integrate legislation on noise protection when selecting noise protection measures	- explain the noise maps - distinguish primary and secondary measures for noise protection - interpret the legislation in the field of noise management

FORM 2

1) Course teachers: Associate. prof. Ana Lončarić Božić PhD	
2) Name of the course: Environmental management systems	
3) Study programme: undergraduate	
4) Status of the course: mandatory	
5) Expected learning outcomes at the level of the course (4-10 learning outcomes): 1. the ability to apply the methodology of Environmental management systems based on Deming's cycle of continual improvement 2. the ability to analyse processes, activities and corresponding environmental aspects and impacts 3.the ability to propose preventive measure for potential environmental problems related to different processes and activities 4. the ability to recognise and response to the specific environmental issues related to inherent risks of chemical industry	**6) Learning outcomes at the level of the study programme:** 1. the ability to apply basics of professional protection of local and global environment, environmental development and control, and environmental legislation ; 2. the ability to perform critical analysis of environmental problems. 3. the ability to understand and solve environmental issues using environmental management tools

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Basic principles of sustainable development; Introduction to Environmental management system (EMS) based on Demig's cycle; ISO 14001	- adopt the preventive approach in environmental protection and management -understand the role of Demings' cycle in continual improvement - understand the significance of the main elements and their correlation within EMS - understand the requirements of ISO 14001 -analyse processes, activities and corresponding environmental aspects and impacts	- describe and explain the basic principles of preventive approach and EMS as a sustainable development tool -specify the elements of Demings' cycle and describe the concept of continual improvement - explain the requirements for environmental policy according to ISO 14001 -set "smart "EMS objectives based on given examples -define environmental aspects and impacts based on activities described in given

FORM 2

		case study - distinguish types of EMS documentation
2. Cleaner production, Life Cycle Analysis (LCA) and Responsible care	- understand and adopt the methodology of Cleaner production, Life Cycle Analysis (LCA) and Responsible care - correlate sources of waste in Cleaner production with corresponsive preventive measures - understand the importance and main characteristics of programme Responsible care in chemical industry	-describe and explain the basic elements of Cleaner production, Life Cycle Analysis (LCA) and Responsible care methodology -classify types of waste sources in Cleaner production -specify and explain applicability of preventive measures in Cleaner production
		-describe inherent environmental and health risks in chemical industry -explain principles of Responsible care their correlation with the EMS methodology

FORM 2

1)Course teachers: Assistant prof. Hrvoje Kušić, PhD	
2)Name of the course: Waste management	
3)Study programme: undergraduate	
4) Status of the course: mandatory	
5) Expected learning outcomes at the level of the course (4-10 learning outcomes): 1. the ability to understand basic terms and adopt the main principles of waste management 2. the ability to understand the problem of waste generation as one of the most important environmental issues 3. the ability to understand and apply the hierarchy of waste management according to the principles of sustainable development 4. the ability to correlate sources of waste generation and appropriate minimisation strategies 5. the ability to classify different types of waste according to their characteristics 6. the ability to select appropriate waste management method according to identified characteristics of waste	**6) Learning outcomes at the level of the study programme:** 1. the ability to apply professional knowledge regarding waste management and environmental legislation ; 2. the ability to perform critical analysis of environmental problems related to the unsustainable waste management practice 3. the ability to interpret the information on waste sources

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Waste; basic principles, legal framework, introduction to waste management	- adopt basic terms in waste management all participants in integrated waste management system -understand the problem of waste as one of the key issues in environmental protection -understand the national Strategy, and roles and responsibilities of all participants in Waste management	- define basic terms in waste management -specify the main problems of waste -classify the sources of waste, their significance and potential environmental impact -specify and explain the main goals of national Strategy of Waste management, and identify the roles of participants

FORM 2

2. Sustainable development and waste management	- understand and adopt the hierarchy of waste management according to the principles of sustainable development -recognise the opportunities and adopt the methodology of waste minimization regarding the type of waste source	-describe and explain t hierarchy of waste management -correlate the sources of waste with the opportunities of preventive measures for the waste minimisation - describe the methodology of Cleaner production
3.Types of waste, waste characteristics and management strategies	- be acquainted with the characteristics of specific types and sources of waste –adopt measures of waste management regarding the waste characteristics and legal requirements ***Kriteriji vrednovanja*** - definirati vrste otpada i njihove karakteristike - procijeniti mogućnosti vrednovanja pojedinih vrsta otpada - navesti osnovne zakonske zahtjeve vezane uz pojedine vrste otpada i mjere postupanja s otpadom	-classify types of waste and specify their characteristics -assess the opportunities for valorisation of specific types of wastes through reuse, recycling and recovery strategies -specify legal requirements for different types of waste and required management measure

FORM 2

1) Course teacher: Prof. Đurđa Vasić-Rački Ph. D., Assoc. prof. Vanja Kosor Ph. D.

2) Name of the course: Reactors and bioreactors

3) Study programme (undergraduate, graduate): undergraduate

4) Status of the course: Active

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. The definition of process variables and parameters of chemical reactors and bioreactors

2. Carrying out kinetic models based on the physical picture of the process or conducted kinetic experiments

3. Distinguishing kinetics of reactions in homogeneous and heterogeneous systems

4. Differentiating catalysts and biocatalysts according to the structure, function and conditions of use.

5. Detached reactors and bioreactors according to performance

6. Set up mathematical models of processes with chemical and biochemical reactions in various types of reactor (kinetic and reactor model)

7. Solved analytically and numerically (simulate) mathematical models of chemical and biochemical reactions in various types of reactor

8. Evaluate the value of kinetic model parameters based on the given experimental data by a computer program SCIENTIST

6) Learning outcomes at the level of the study programme:

1. Apply the methodology of chemical engineering when choosing a reactor for the implementation of certain types of reactions

2. Apply mathematical numerical and / or analytical methods in the assessment of parameters of kinetic models

3. Apply the acquired knowledge in modeling and design of chemical reactors and bioreactors

4. Apply mathematical methods, models and techniques in solving case studies

7) Teaching units with the corresponding learning outcomes and evaluation criteria

FORM 2

Teaching unit	**Learning outcomes**	**Evaluation criteria**
1. The concept of process space and a chemical reactor	- The definition of a chemical reactor as the basic unit of chemical processes - Define the process space, system boundaries, and input - output variables of the process - Place the energy and mass balance of case studies - Define the basic division and classification of chemical reactors	-Distinguish the main types of chemical reactors - Apply the law of conservation of mass and mass balance set default process
2. The ideal reactor types and their mathematical models	- Define reactor model of an ideal batch reactor - Define the reactor model of an ideal stirred tank reactor - Define reactor model of and ideal tubular reactor-	- Apply the features of an ideal batch reactor when performing the balance of heat and mass - Apply the features of an ideal flow stirred tank reactor when performing the balance of heat and mass - Apply the features of an ideal tubular reactor when performing mass balance and heat
3. Kinetic models in homogeneous and heterogeneous systems	- Define the dependence of the reaction rate on the temperature - Define the characteristics of the kinetics of reactions in homogeneous systems - Define the characteristics of the kinetics of reactions in heterogeneous systems	- Distinguish the basic features of chemical reactions in homogeneous and heterogeneous systems - Apply the Arrhenius dependence in determining the activation energy spent kinetic experiment
4. Basic groups of reactors for reactions in homogeneous and heterogeneous systems	- Describe reactors for the implementation of the non-catalytic reaction fluid solid - Describe reactors gas - liquids - Describe reactors for the	- Apply the core model or a model of continuous reaction kinetics when defining noncatalytic reaction fluid solid - Apply Whitman's theory of the boundary layer in the

FORM 2

	implementation of catalytic reactions with solid catalysts	absorption of the reactant gas in the liquid phase - Apply the kinetic model of Hougen Watson in the implementation of catalytic heterogeneous reactions
5. Experimental methods in kinetic studies	- Define the integral method to estimate parameters of the kinetic model - Define the differential method to estimate parameters of the kinetic model - Define the modified differential method to estimate parameters of the kinetic model - Define the criterion of agreement of experimental data and calculated values	- Apply different numerical methods estimate the parameters depending on the complexity of the reaction system (kinetic model and experimental reactor) - Critically choose the best kinetic model that based on criteria mean square deviation, described for an kinetic experiment performed
6. The concept and features of biological material	- Define the specificities of biological material as a catalyst in relation to classical chemical catalyst - Define the differences of chemical and biochemical engineering arising from differences catalysts and biocatalysts - Define the differences between bioprocesses and chemical processes, and biochemical reactors	- Distinguish bioprocess of chemical processes - Distinguish catalysts and biocatalysts - Distinguish features biochemical reactors
7. Biocatalysts and biocatalysis	- Define the concept of biocatalysts - Define the structure of the biocatalyst - Define the advantages and disadvantages of biocatalysts in comparison to conventional catalysts	- Identify the advantages and disadvantages of the use of biocatalysts - Identify the reproducibility of sources from which the biocatalysts are produced

FORM 2

	- Define the sources for obtaining biocatalysts	
8. Enzymatic reaction kinetics	- Define the kinetics of enzyme-catalyzed reactions: Michaelis-Menten kinetics - Define the method of initial reaction rates	- Perform kinetic model of Michaelis Menten on the mechanism based enzyme-catalyzed reactions - Evaluate the reaction rate on the basis of given experimental data, which are measured by initial reaction rate method - Solve the case study with the default experimental data using a differential or integral method parameter estimation
9. Microbiological kinetics	- Define bioprocess - Define the cellular metabolism - Define utilization reactions in bioprocessing - Define the rate of growth of microorganisms and the specific growth rate of biomass: Monod kinetics	- Recognize differences in the stoichiometry of chemical reactions and bioprocesses - In the given example, calculate the rate of growth of microorganisms using a mathematical model
10. Overview of the basic types of bioreactors	- Set the balance of substances in various types of bioreactors - Identify which of the proposed reactor types is the most suitable for use of the inhibition phenomena by substrate or product	- List the different types of reactors used in biochemical engineering and set their differences - Be able to recognize when used type of reactor, depending on the kinetics of enzyme-catalyzed reactions and kinetics of bioprocesses
11. Aeration and mixing in biological systems	- Define the specificities of mixing and aeration in biological systems - To outline and describe the transfer of oxygen in biological system.	- Write mathematical expressions that describe gas diffusion in the liquid system - Specify special requirements of interference in biological systems

FORM 2

1) Course teacher: Prof. Bruno Zelić, PhD

2) Name of the course: Analysis and Modeling of Environmental Processes

3) Study programme (undergraduate, graduate): Undergraduate

4) Status of the course: Required

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. to apply basic principles of mass and energy conservation on physical, chemical and biochemical processes
2. to define process space, system borders, and inlet and outlet process parameters
3. to develop mathematical models of engineering and environmental processes
4. to apply numerical methods for solving of mathematical model
5. to define experimental plan
6. to optimize process using experimental and model simulation results
7. to apply numerical methods for process optimization

6) Learning outcomes at the level of the study programme:

1. to apply and optimize chemical and related industrial processes
2. to apply methodology of chemical engineering for process development
3. to manage and schedule processes
4. to manage and schedule time
5. to apply mathematical methods, models and techniques for solving of case studies

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Mathematical model of the process	- to apply basic principles of mass and energy conservation on physical, chemical and biochemical processes - to define process space, system borders, and inlet and outlet process parameters - to develop mathematical models of engineering and	- construct process scheme for case study and identify inlet and outlet process streams and parameters - determine the base for calculation and standard conditions - apply the principle of mass and energy conservation and develop mass and energy

FORM 2

	environmental processes	balances for case study
2. Numerical methods and mathematical modeling	- to apply numerical methods for solving of mathematical models	- solve resulting system of independent linear equations or nonlinear equations or differential equations or partial differential equations
3. Process optimization	- to define experimental plan - to optimize process using experimental and model simulation results - to apply numerical methods for process optimization	- define experimental plan for case study - optimize the process using required optimization method

FORM 2

1) Course teacher: Veljko Filipan, Domagoj Vrsaljko

2) Name of the course: Process equipment in ecoengineering

3) Study programme (undergraduate, graduate): Undergraduate (Environmental Engineering)

4) Status of the course: obligatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

After the completion of obligations and passing the exam, it is expected that the students will be able to:

1. Apply the basic rules, symbols and norms during viewing, descripting and specifying of process equipment simple elements

2. Apply the basic principles of engineering mechanics to simple parts and process equipment systems

3. Understand the basic properties and engineering materials test methods

4. Interpret purpose, construction solutions, properties and application of the process equipment basic elements and systems and assess their most important characteristics

5. Know how to choose the appropriate elements and sets of equipment from the standpoint of efficiency and economy

6) Learning outcomes at the level of the study programme:

After the completion of obligations and passing the exam, it is expected that the students will be able to:

1. Apply knowledge and understanding of elementary engineering subjects

2. Apply knowledge of elementary engineering for calculating balance of matter and energy

2. Apply basic professional knowledge of energy management

4. Create a base of engineering knowledge as a starting point for improving the technology with minimal impact on environment

5. Analyse, synthesize and model complete technologies with the least impact on environment

6. Acquire knowledge related to processes taking place in the environment or in interaction with the environment

7. Understand today's technologies and the environmental impact

8. Adaptability to team work

FORM 2

7) Teaching units with the corresponding learning outcomes and evaluation criteria		
Teaching unit	**Learning outcomes**	**Evaluation criteria**
1. Introduction, technical documentation	- Apply the basic rules and norms at the display and description of simple elements of process equipment - Apply graphic symbols in process diagrams and charts	- In the written test demonstrate the ability to sketch orthogonal and perspective view of a basic element and properly mark the most important measures - In the written test demonstrate the ability to sketch graphic symbols of simple pieces of equipment
2. Fundamentals of mechanical behaviour of the process equipment parts	- apply the basic principles of engineering mechanics to simple parts and process equipment systems - Define a causal relationship between load, stress and strain - Distinguish basic loads of simple pieces of equipment and devices	- In the written test demonstrate the ability to define static and inertial forces and set the conditions of equilibrium and determine all unknowns for simple systems - In the written test demonstrate the ability to determine the amount of the maximum stress and strain for simply loaded element

FORM 2

3. Materials for equipment and devices	- Understand the basic properties and methods for testing of engineering materials - Define possible basic procedures for creating and connecting equipment elements - Understand the criteria for the selection of materials for individual pieces of equipment	- In the written test demonstrate the ability to sketch diagrams of static strength and explain the meaning of certain areas - In the oral exam determine the most important properties of a material for a given application
4. Basic elements and circuits of process equipment	- Understand the purpose, design and construction solutions, properties and application of the basic elements and systems of process equipment (rotating systems - shafts, drive shafts, rotors, clutches, brakes, elastic bonds and damping shock and vibration, bearings) - Assess the characteristics and be able to choose the gear and drives, power apparatus (electric motors, engines and turbines) and construction equipment (pumps, compressors, blowers and fans) - Differentiate elements and equipment of pipelines (pipes, valves, sealing, insulation)	-- In the oral exam interpret basic characteristics of an application elements and systems - In the oral exam select suitable elements and circuits by application - In the oral exam determine the characteristics of serial or parallel-connected active or passive elements of the hydraulic and pneumatic systems

FORM 2

	- Process equipment for treatment of solid waste (conveyors, screw conveyors,	
5. Process equipment systems by application	bulldozers, cranes, crushers) - Air purification equipment (filters, cyclones, scrubbers) - Water treatment equipment (tanks, sedimentation tanks, filter presses, oil separators, mixers) - Equipment for thermal waste treatment (stoves, furnaces, incinerators); - Measuring equipment and instruments in environmental protection, display and analysis of measurement results - Standardization and typing of equipment, optimization; specifications and selection of equipment	- In the oral exam describe the process scheme of the system and describe the most important parts and their purpose - In the oral exam select suitable elements and circuits from the standpoint of efficiency and economy - In the oral exam demonstrate the ability to fulfil the specifications for equipment selection

FORM 2

1)Course teachers: Prof. Sanja Papić, PhD
Assoc. prof. Ana Lončarić Božić, PhD
Assist. prof. Hrvoje Kušić, PhD

2) Name of the course: Environmental Impact Assessment

3) Study programme: undergraduate

4) Status of the course: mandatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):	**6) Learning outcomes at the level of the study programme:**
1. define participating parties in Environmental impact assessment (EIA) procedure. To get acquaint with the basic principles and the legal framework of EIA 2. understand the importance of environmental impact assessment in the decision making process within the economy sector, and identify the sociological aspects of EIA. 3. predict and evaluate environmental impacts and propose appropriate mitigation measures 4. adopt the systematic approach to the identification of the processes on particular location contributing to the overall environmental impact. 5. identify the opportunities of environmental impact control using environmental management system tools. 6. be acquainted with the elements of	1. understand the importance of strategic environmental impact assessment (SEA) and its' influence on development of chemical industry on the national and regional level. 2. identify the correlation of Environmental impact assessment (EIA) with the scientific aspects within the field of environmental engineering. 3. understand the importance of EIA and SEA as environmental management tools 4. adopt interdisciplinary approach to study the correlation between the environmental engineering and EIA procedure based on chemical engineering methodology using mathematical modeling and process optimization

FORM 2

Environmental impact assessment study. 7. understand the importance of EIA as an integral part of technical project documentation. 8. understand the importance of EIA as a tool in creating the environmental policy and management in chemical industry.	

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1.Paricipating parties in the Environmental impact assessment (EIA) procedure; main terms and definitions; legal framework	- adopt interdisciplinary approach and understand the need for contribution of natural, technical and social sciences in analysis environmental impact related to the natural processes and anthropogenic activities - understand the purpose and benefits of EIA - adopt the main principles of EIA - understand the significance and characteristics of different types of environmental impacts and significant impacts - be acquainted with the requirements of Environmental protection law and EIA and SEA	- explain the main terms in EIA - specify different levels in EIA and SEA - explain the integration of health and sociological aspects in EIA - describe EIA stages including screening and scoping, identification and evaluation of impacts, determination of mitigation measures, decision making, control, and analysis -specify goals and describe methods in EIA screening stage -give examples of positive and negative screening list
2. Prediction, mitigation and evaluation of environmental impacts .	- adopt environmental impact identification and evaluation methodology including different methods and models for impact prediction - be acquainted with the elements of location description, assessment	- apply environmental impact identification and evaluation methodology based on given examples - outline the elements of location description required in EIA - describe characteristics of

FORM 2

	techniques, environmental components and uncertainties in EIA - - understand the mitigation measures and hierarchy of their application within EIA	different assessment techniques and their applicability based on given case studies - -apply appropriate method and/or model to evaluate environmental impact within EIA based on given example -correlate environmental impacts and corresponding mitigation measures with regard to EIA hierarchy
3. Uncertainty in EIA process; significance concept Nesigurnost u PUO procesu. Zajednički elementi i referentne vrijednosti pri određivanju nesigurnosti	-understand the uncertainty in EIA process and its' importance in interpretation of assessment results -adopt the significance concept in EIA process and be acquainted with the types of reference values	-explain the significance concept in EIA process -explain the uncertainty in EIA process based on given examples
4. Presentation of the EIA study; positive and negative aspects of public participation	- adopt the EIA procedure and Environmental management tools -understand the role of EIA within the frame of national legislation - understand the aspects of public participation in EIA	-demonstrate screening methods based on give examples -describe the main project characteristics, location and types of impacts based on given examples - specify the requirements for public involvement in EIA -describe EIA post-decision monitoring audit -perform EIA based on given case study

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FORM 2

1) Course teacher: Igor Sutlović, associate professor

2) Name of the course: Energy management

3) Study programme (undergraduate, graduate): undergraduate

4) Status of the course: obligatory

5) Expected learning outcomes at the level of the course:

1. recognize energy consumption trends
2. know forms of energy and their carriers
3. know processes of energy transformation
4. know main sources of environmental impact in energy use
5. know role of renewable energy sources

6) Learning outcomes at the level of the study programme:

1. know the role of energy in society
2. recognize connection between socio-economic data and energy consumption
3. define how to decrease environmental impact of energy use locally and globally

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Role of energy in society	- know relevant statistics, domestic and global	- set connection between energy consumption and other influencing data
2. Energy classification	- know classification regarding direction of energy transformation and origin of primary energy source	- classify certain form of energy
3. Energy transformations	- know how primary sources can be transformed	- for certain process define possible transformation
4. Environmental impact of energy transformations	- recognize specific environmental impact of various categories of energy use - propose how to decrease it	- define environmental impact of certain energy use
5. Renewable energy sources	- know advantages and disadvantages of RES compared to non-renewables	- know advantages of certain RES

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FORM 2

a) Course teacher: Assoc. Prof. Nenad Bolf, Ph. D.	
b) Course: Process Measurements and Control	
c) Title of the study program: Chemical engineering	
d) University education level: Undergraduate	
e) Academical year: 3	**f) Term : 6**
g) Teaching method:	**h) Hours (weekly)**
1. Lectures	2
2. Practical (laboratory) work	1
3. Seminar	-
4. Field teaching (days)	-

h) Aim of the course:

Instruct students to use the software package MATLAB/Simulink and its advanced functions for chemical engineering calculation, display and analysis of measurement data, modelling and process optimization.

i) Course learning outcomes (4-8):	**j) Program learning outcomes:**
1. Solve systems of equations by matrix calculation in a software package	1. To apply chemical engineering methodology in the process development
2. Apply advanced features for analyzing and displaying data	2. To apply mathematic methods, models and techniques in solving examples
3. Perform symbolic functions and calculations	3. To perform process measurements and to control processes
4. Analyze measurement data using the Statistics, Curve Fitting, Spline and System Identification Toolbox	4. To analyze and optimize chemical and related industry processes
5. Develop process models in a graphical user interface using the Simulink	
6. Solve examples of continuous, discrete and hybrid systems	

k) Teaching units with associated learning outcomes and evaluation criteria

Teaching unit	**Learning outcome**	**Evaluation criteria**

MATLAB / Simulink. Environment, interface and basic operations. Manipulating vector, matrices and fields. Data structures and programming.	Solve systems of equations by matrix calculation using the software package.	Solve the system of equations by matrix calculation.
Process and system simulation. Methods and tools for simulation. Plotting and graphic display.	Apply advanced features for solving, displaying and data analyzing.	Solve and analyze the dynamic model of process/ system applying numerical methods.
Symbolic computation fundamentals. Using functions for symbolic computation.	Solve symbolic expressions and equations and linear algebra examples. Apply special functions in the graphical environment.	Solve given symbolic expression or equation.
Data processing in Curve Fitting Toolbox. Parametric and nonparametric fitting. Spline Toolbox.	Process measurement data and calculate fitting statistical. Apply the method of linear and non-linear regression using parametric and non-parametric models. Linear and nonlinear fitting procedures.	Implement regression analysis and data processing in the program interface.
System identification. Parametric and non-parametric identification. Model validation.	Develop a dynamic model of process/system using identification methods. Derive the model in a graphical environment.	Solve the example of dynamic identification based on the real plant data.
Simulink fundamentals. Developing process/system model. MATLAB/Simulink connectivity and interaction.	Develop continuous, discrete, and hybrid models of linear and nonlinear systems.	Develop a process/system model in a graphical environment by using block diagrams.
Programming in the Simulink graphical environment.	Simulate and analyze dynamic systems in the graphical environment.	Conduct a simulation and analyze the simulation results.

l) Student assessment

1. Assessment methods	**2. Examination**
- homework and seminars - colloquia/partial exams - computer simulation	- continuous monitoring and evaluating - computer exams

m) Evaluation criterion

<table>
<tr><td colspan="4">1. Continuous monitoring and evaluating</td></tr>
<tr><td colspan="2">Activity and corresponding number of points</td><td colspan="2">Evaluation criterion</td></tr>
<tr><td>Activity</td><td>Points</td><td>Grade</td><td>Points</td></tr>
<tr><td>- computer simulation
- colloquia/partial exams
- participation
TOTAL</td><td>55
40
5
100</td><td>sufficient (2)
good (3)
very good (4)
excellent (5)</td><td>60-69
70-79
80-89
90-100</td></tr>
<tr><td colspan="4">2. Written exam</td></tr>
<tr><td colspan="2">Activity and corresponding number of points</td><td colspan="2">Evaluation criterion</td></tr>
<tr><td>Activity</td><td>Points</td><td>Grade</td><td>Points</td></tr>
<tr><td>- Solving of a system of equation</td><td>20</td><td rowspan="6">sufficient (2)
good (3)
very good (4)
excellent (5)</td><td rowspan="6">60-69
70-79
80-89
90-100</td></tr>
<tr><td>- Solving of a symbolic equation</td><td>10</td></tr>
<tr><td>- Statistical data analysis</td><td>20</td></tr>
<tr><td>- Identifying process models</td><td>25</td></tr>
<tr><td>- Model development in the Simulink</td><td>25</td></tr>
<tr><td>TOTAL</td><td>100</td></tr>
<tr><td colspan="4">3. Oral exam – as required</td></tr>
</table>

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1) Course teacher: Dr. Tatjana Gazivoda Kraljević, assis. prof.; Dr. Marijana Hranjec, assoc. prof.

2) Name of the course: Biochemistry

3) Study programme (undergraduate, graduate): undergraduate

4) Status of the course: Optional

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. Explain the biochemical processes and metabolic reactions in various organs and tissues that are important for the understanding of physiological and pathological processes.

2. Explain the conditionality of three-dimensional structure and biological activity on the protein example.

3. Discuss the creation and storage of metabolic energy and the overall strategy of metabolism.

4. Define the basic principles and the importance of the central dogma of molecular biology and the basic concepts related to the formation and structure of nucleic acids in living organisms.

5. Explain the mechanisms of DNA replication, transcription of DNA and translation of RNA.

6) Learning outcomes at the level of the study programme:

1. Adopt a basic general knowledge of mathematics, physics, chemistry and biology

2. Appply methodology of theoretical interpretation of experimental results

3. Critical analyse the environmental problems

4. Study skills and competences needed for continuing professional development.

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. The conformation and dynamics. Conditionality of three-dimensional structure and biological activity on the protein example. Myoglobin and	1. Recognize the relationship between the natural and biomedical knowledge 2. Compare the diversity of functions of proteins and	1. Able to write a structure of 20 amino acids. 2. Define the structure of proteins, from primary to quaternary.

FORM 2

hemoglobin. Enzymes. Collagen and elastin.	peptides. 3. Determine the amino acid structure of the protein, peptide bond, conformation, dynamic aspects of the structure and function of proteins. 4. Distinguish proteins with special functions, hemoglobin, a model globular protein and hemoglobin interaction with ligands, and myoglobin. 5. Explain the conditionality of the structure and function fibril proteins collagen and elastin 6. Explain the basics of enzyme catalysis, allosteric regulation of enzyme activity, activators and inhibitors, coenzymes and prosthetic groups	3. Apply the knowledge of the structure and function of proteins in the hemoglobin and myoglobin, and fibrillar proteins collagen and elastin, as well as proteins with specific functions. 4. Explain the regulation of metabolic activities of important enzymes, coenzymes and prosthetic groups
2. The creation and storage of metabolic energy. The overall strategy of metabolism.	1. Explain the basic concepts and metabolic properties. 2. Explain the metabolic degradation of glucose - the flow pathway, control and regulation, allosteric regulated enzymes, ATP production, the importance of NADH oxidation. 3. Sketch cycle gluconeogenesis, citric acid cycle, Cori cycle. 4. Explain the cellular bioenergetics, ATP cycle, respiratory chain and oxidative phosphorylation, oxidation cascade coenzyme NADH and $FADH_2$. 5. Write the basic levels of	1. Notice the differences in the levels of certain metabolic cycles. 2. Define the common precursors over the cycle, and the input and output components. 3. Apply knowledge of the overall strategy of metabolism in each cycle.

FORM 2

	fat metabolism: decomposition of triacylglycerols and b-oxidation of fatty acids. 6. Compare the urea cycle,	
	different ways of excretion of nitrogen from the body, alanine and glutamine cycle transfer of nitrogen from various tissues to the liver, oxidative deamination of glutamate, the flow of urea cycle, and the mechanism of toxicity of NH4 + ions in the brain.	
3. The central dogma of molecular biology.	1. Define the basic principles and the importance of the central dogma of molecular biology. 2. Explain the formation of nucleic acids in living organisms. 3. Define the higher structural forms of DNA in prokaryotes and eukaryotes. 4. Explain the mechanisms of DNA replication, transcription of DNA and translation of RNA.	1. Explain the concept and importance of the central dogma of molecular biology by own way. 2. Explain the way in which the nucleic acids are created in living organisms. 3. Explain the way for the formation of higher structural forms of DNA in prokaryotes and eukaryotes. 4. Explain the mechanisms of DNA replication, transcription of DNA and RNA translation. 5. Distinguish the replication of DNA, transcription of DNA and translation of RNA.

FORM 2

1) Course teacher: Prof.dr.sc. Đurđa Vasić-Rački

2) Name of the course: Eco-engineering laboratory

3) Study programme (undergraduate, graduate): graduate

4) Status of the course:

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. Mastering solving project task-threads in a team or independently.
2. Connect the task to search for literature-site; Library.
3. Independent Power-point used for the preparation of presentations.
4. Mastering in writing of the final report: introduction, theoretical part, experimental part, presentation and discussion of results, conclusions, literature
5. Mastering in presenting in front of a wider audience

6) Learning outcomes at the level of the study programme:

1. Enable students to gain more environmental engineering practices,
2. Applying the methodology of chemical engineering to solve issues related to environmental protection.

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. The first meeting of all the teachers and students, in which teachers present project topics to students, and students are allocated for a specific project.	- Defining issue of student projects	- Explain the topics of student projects
2. Students meet with teachers and mentors to elaborate the project topic	- Elaboration of project topics	- Recognition of project topics
3. The second meeting of all teachers and students in which students exhibit their	- The definition of the topic by the students	- Explanation of the topics of student projects by students

FORM 2

intention to seeing the project topics, and review of the literature intention to seeing the project topics, and review of the literature.		
4. Students meet mentors to elaborate experimental plan, and to introduce to laboratory	- Defining the experimental plan	- Understanding of the experimental plan
5. Students meet with mentors and according experimental design, carried out experiments in the laboratory	- Defining experimental techniques	- Understanding of experimental techniques
6. The fourth meeting of all teachers and students in which students present the results of their experimental measurements and their analysis of experimental data.	- Defining the methods of analysis of experimental data	- Understanding the used methods of analyzing the experimental data
7. The final meeting of all teachers and students in in which students present the whole project	- Demonstrating work in a team or individual work in solving given problems	-Way of presenting of final presentation - Written final report

FORM 2

1) Course teachers: Assoc. prof. dr. sc. Zvjezdana Findrik Blažević, Assoc. prof. dr. sc. Ana Vrsalović Presečki

2) Name of the course: Bioreaction technique

3) Study programme (undergraduate, graduate): graduate

4) Status of the course: optional

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. To distinguish homogeneous and heterogeneous biocatalysis
2. To distinguish heterogeneous biocatalysts according to the method of their preparation
3. To define basic parameters that characterize immobilized biocatalyst
4. To estimate the values of kinetic parameters of the complex enzymatic system from the experimental data
5. To develop mathematical model for the complex enzymatic system (multienzyme), as well as for the process catalyzed by whole cells as biocatalyst in different types of reactors
6. To simulate the process in different types of reactor at different initial process conditions
7. To carry out the biotransformation catalyzed by purifies enzyme and permeabilized whole microorganism cells
8. To define the methods of bioproduct separation

6) Learning outcomes at the level of the study programme:

1. Application of chemical engineering methodology in development of mathematical models for complex reaction systems
2. Applications of mathematical methods and computer techniques for evaluation of model parameters and process simulation
3. Optimization of reaction system (initial process conditions) by using the mathematical model
4. Gaining practical experience in collecting experimental data in the lab

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Methods of preparation of heterogeneous biocatalysts	- to define the methods of preparation of heterogeneous biocatalyst - to define and explain	- making the difference between homogeneous and hetergeneous catalysis - to recognize the advantages

FORM 2

	advantages and disadvantages of each method of immobilization - to define and explain the differences between immobilized enzymes and whole cells - to define different factors that influence the choice of biocatalyst immobilization method	and disadvantages of heterogeneous biocatalysts - evaluation of the application are of immobilized enzymes and immobilized whole cells
2. Characterization of immobilized biocatalyst	- to define reaction engineering parameters of heterogeneous biocatalysts and discuss the methods of their determination - to define the methods of determination of the activity of immobilized biocatalyst - to define the effectiveness of immobilized biocatalyst - to define Thiele modulus	- numbering the limitation of the use of immobilized biocatalysts - ability to assesss wether the process is diffusion limited on the basis of experimental data - ability to determine the activity of immobilized biocatalyst from the experimental data
3. The application of immobilized biocatalysts	- to discuss the application of heterogeneous biocatalysts and immobilized proteins in general	- ability to discuss the importance of immobilized proteins
4. Biocatalysts in non-conventional media	- to define the non-conventional media used in biotransformations - to define the advantages and disadvantages of the use of non-conventional media	- recognition of purpose of different reaction media and importance of the choice
5. Stability and deactivation of biocatalysts	- to discuss the types of biocatalyst stability - to discuss the methods of determination of operational stability	- ability to determine of operational stability of biocatalyst from the experimental data - ability to estimate the biocatalyst deactivation constants from the experimental data and its incorporation in the kinetic model of the process
6. Mathematical modeling of complex enzymatic systems with coenzyme regeneration	- to develop and solve the mathematical model for multi-enzyme reaction system in different reactor types	- ability to develop and apply the mathematical for simulation and optimization of the reaction system

FORM 2

	- to evaluate and apply the developed mathematical model and predict the process outcome by its use - to select the optimal conditions of the process by using the mathematical model	
7. Bioprocesses catalyzed by whole cells	- to identify the products of the process catalyzed by whole cells - to define the conditions of cell growth - to define and explain the characteristics of cell methabolism - to number the methods of metabolism regulation	- ability to determine the possibility of production of certain product by using whole cells
8. Mathematical modeling of biomass growth	- to explain the kinetic model of microbial growth - to explain the kinetic model of substrate consumption - to explain the kinetic model of product synthesis - to evaluate the process efficiency	- ability to estimate kinetic parameters of the process - ability to develop model of microbial growth in different types of reactor - ability to determine the yield, substrate conversion, space-time yield
9. Types of bioreactors and bioprocess methods for microbial growth	- to define the types of bioreactor - to define the aeration - to define the types of mixing - to distinguish the types of bioprocess methods for microbial growth - to define the methods for bioprocess monitoring	- ability to determine the optimal bioreactor type for a single process - to estimate the volume coefficient of oxygen transfer - ability to determine the optimal type of mixing in bioreactor for specific process - ability to determine the type of bioprocess implementation
10. Bioproduct separation processes	- to define the methods of cell separation - to define the methods for separation of products from the cell - to define the methods of purification and concentration of bioproducts	- ability to determine the optimal way of product separation

FORM 2

1) Course teacher: Prof. Felicita Briški, PhD.

2) Name of the course: Environmental Ecology

3) Study programme - graduate: Environmental Engineering

4) Status of the course: optional

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. to apply the principles of industrial ecology in industrial systems
2. to calculate the flow of matter and energy for the selected production process
3. to assess the effectiveness metrics for different levels (local, national, global)
4. to choose data and sketch a simple diagram of the production system

6) Learning outcomes at the level of the study programme:

1. to point to the systematic approach of fitting of industrial systems in the natural environment
2. to analyze and evaluate the state of the environment
3. to use specialized tools for designing sustainable industrial system
4. to support collaboration and promote a team approach to solving an environmental problems

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Environment and anthrophosphere, status of resources, and industrial systems	- explain the impact and integration of anthrophosphere in the environment and regulatory approach to pollution prevention - to identify the availability and accessibility of natural resources - to apply the principles of industrial ecology in industrial systems - to analyze the material and energy flow in the industrial system	- describe and schematically show the anthrophosphere integration in the environment - estimate availability and accessibility of a given natural resource, and evaluate its use - explain the design of the production process according to the principles of industrial ecology - evaluate the effectiveness of a given industrial process based on the material and energy productivity
2. Industrial ecosystems, design and product	- to compare the natural and industrial metabolism and	- explain the features of natural and industrial

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development, and life-cycles of industrial products	define the components of the industrial ecosystem - to organize a team and implement industrial ecology tools for designing a new product / process - to apply life-cycle assessment	metabolism, sketch and compare an open and closed industrial system - define the team members and choose the tools to develop a given product / process - analyze the life-cycle of a given product (e.g. chemical industry, organic synthesis)
3. Corporate industrial ecology toolbox and implementation of industrial ecology in corporations	- to explain the phases and tools applied in the corporate industrial ecology - to implement environmental management systems in corporations - to implement a policy of pollution prevention in the corporation	- define the phases for implementation the principles of industrial ecology for a given company - select the tools for meeting regulatory requirements for environmental pollution prevention - describe the organizational structure of environmental group in the company and explain the given norm
4. Indicators and Metrics	- to define indicators and metrics - to select indicators and metrics for different spatial scales and organizational entities	- explain the importance and development of indicators and metrics - explain the most common metrics in corporations, and select indicators and metrics for a given company

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FORM 2

1) Course teacher: Veljko Filipan, PhD, full professor; Ante Jukić, PhD, full professor; Zvonimir Glasnović, PhD, associate professor

2) Name of the course: RENEWABLE ENERGY SOURCES

3) Study programme (undergraduate, graduate): graduate

4) Status of the course: elected

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. understand the issues in the field of energy sustainability
2. distinguish different conventional and alternative forms of energy
3. understand the influence of energy transformation on the environment
4. distinguish direct and indirect energy transformation
5. explain the roll and importance of different energy sources
6. define global energy strategy and energy strategy of EU and Croatia

6) Learning outcomes at the level of the study programme:

1. advanced knowledge of elementary engineering subjects
2. efficiency, reliability and adaptability in team work
3. forming their own opinion and understanding global processes
4. efficient work and solving problems integrated by the application of basic and technical sciences
5. understanding of engineering processes and their design

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Basic considerations on renewable energy sources (RES)	-recognize renewable energy systems and trends in their using - understand the role of RES in energy supply systems -list different energy storage systems -explain basic problems of	-explain the terms such as global warming potential, green-house gas effect, sustainable energy, feed in tariffs for RES utilisation -explain favours and problems of a specific RES system -list different energy storage

FORM 2

	RES utilization -define global energy strategy and energy strategy of EU and Croatia -understand the system approach in new energetics	systems and their characteristics -recognise global energy strategy and energy strategy of EU and Croatia -describe the environmental effects of different energy production technologies
2. Solar thermal energy systems (ST)	-explain the possibilities and principles of solar energy utilisation -define solar thermal energy utilisation technologies and equipment -describe working principles of flate plate and concentrating solar thermal collectors -understand the possibilities of solar thermal energy storage	-describe basic principles of solar energy utilisation -list different system equipment for solar thermal energy utilisation -formulate the difference between short and long time solar energy storages
3. Geothermal energy (GE) utilisation	-understand the origin of GE and geothermal gradient -distinguish the advantages and disadvantages of GE -classify the cascade using of GE -understand the technologies of conversion GE to electric energy	-explain the geothermal gradient and GE potentials in Croatia -describe the technologies of GE transformation to electric energy -reproduce the cascade using of GE on an example in Croatia

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FORM 2

1) Course teacher: Prof. Bruno Zelić, PhD

2) Name of the course: Bioseparation Processes

3) Study programme (undergraduate, graduate): Graduate

4) Status of the course: Elective

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. to apply basic principles of mass and energy conservation on physical, chemical and biochemical processes

2. to define process space, system borders, and inlet and outlet process parameters

3. to differentiate steady-state and non steady-state, closed and open process

4. to develop mass and energy balances of case studies

5. to construct process schemes of biochemical industrial processes

6. to differentiate between bioseparation processes needed for separation, isolation and purification of biochemicals

6) Learning outcomes at the level of the study programme:

- to solve problems by the application of basic and technical sciences

- to set up, recognize, formulate and solve engineering problems, including the mass and energy balance

- to apply various analytical techniques, analytical and numerical methods and analytical and program tools in solving engineering problems

- to create an experimental plan and to conduct the experiments to perform the supposed hypothesis

- to create, syntesis integrate activities related to the ecological and sustainable processes

- to understande engineering processes and their design

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Bioseparation processes	- to apply basic principles of mass and energy conservation on physical, chemical and biochemical processes - to define process space, system borders, and inlet and outlet process parameters - to differentiate steady-state and non steady-state, closed	- construct process scheme for case study and identify inlet and outlet process streams and parameters - determine the base for calculation and standard conditions - seek literature data needed for calculation of mass and

FORM 2

	and open process - to develop mass and energy balances of case studies - to construct process schemes of biochemical industrial processes	energy balances - apply the principle of mass and energy conservation and develop mass and energy balances for case study
2. Process integration	- to differentiate between bioseparation processes needed for separation, isolation and purification of biochemicals	- develop integrated bioseparation process for separation, isolation, and purification of target biochemical

FORM 2

1) Course teachers: Associate. prof. Ana Lončarić Božić PhD,
Assistant prof. Hrvoje Kušić PhD

2) Name of the course: Environmental Engineering and Management

3) Study programme: graduate

4) Status of the course: mandatory (module 2)

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):	**6) Learning outcomes at the level of the study programme:**
1. the ability to understand the concept of sustainable development within the environmental engineering and management practice. 2. the ability to correlate the characteristics of pollution sources and the opportunities for their reduction with the features of sustainable technologies 3.the ability to understand the main requirements of national Environmental protection law, IPPC directive and Environmental impact assessment study 4.the ability to apply instruments of sustainable environmental engineering and management practice	1. the ability to apply fundamentals of chemical engineering in identifying and solving problems within the environmental engineering and management practice 2. the ability to understand the role of chemical engineering in proactive approach within the environmental engineering and management practice. 3. the ability to apply fundamental knowledge and methodological competences for solving environmental problems within the environmental engineering and management practice.

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	**Learning outcomes**	**Evaluation criteria**
1.Introduction to environmental engineering and management; Principles of proactive approach in integrated environmental management	- be acquainted with the key requirements of national Environmental protection law -adopt main terms in environmental engineering and management -understand the concept of sustainable development as a pillar of environmental management -adopt basic principles and elements of preventive approach in environmental	- explain the main terms in environmental engineering and management - identify sources of environmental pollution i.e. emission in soil, air and water -explain the principles of noise, light and odour pollution control -explain and apply proactive approach in waste management based on Cleaner production methodology

FORM 2

	engineering and management - understand the role of chemical engineering in environmental protection and management	- specify and apply the main principles in environmental management based on presented case study
2. Instruments of sustainable environmental management	-be acquainted with technologies of waste minimization and management - understand the risk assessment and management methodology -understand the basic	- specify the correlation between Environmental management systems (EMS) and other management systems such as QMS and OHSAS - explain the term Best available technology as a key
	principles of Environmental management systems -adopt instruments of sustainable environmental management (EMS,CP, RC) - be acquainted with the main features of IPPC directive -understand principles of EMAS and its integration in requirements national Environmental protection legislation	component of IPPC directive - explain the concept and advantages of Integrated environmental management systems (IMS)

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1) Course teacher: Prof. Sanja Papić, PhD

Assoc. Prof. Ana Lončarić Božić, PhD

2) Name of the course: Risk Assessment

3) Study programme: graduate

4) Status of the course: mandatory (module 2)

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. Define risk and explain the categories of risk, the way of expressing risk, the risk assessment procedure and risk management.

2. Describe and classify the test methods as a vital component of the environmental risk assessment of chemicals.

3. Define the main factors in making an environmental risk assessment of chemicals and explain the assessment procedure.

4. Define and explain the major components of risk assessment to human health from chemicals.

5. Recognise legal requirements and basic elements of major accident hazards control for the operators of Seveso industrial sites

6. Identify the correlation of waste management activities with specific health and safety, and environmental risks.

7. Understand the risk assessment frameworks for household waste landfills and correlate specific activities and exposure paths with the corresponding risks.

8.Understand the methodology of data collection and analysis within the process of risk assessment

9.Adopt and apply qualitative and quantitative methods in risk assessment process

6) Learning outcomes at the level of the study programme:

1. Basic professional knowledge of risk assessment and management in order to protect human health and the environment.
2. Involvement in the team work on the study on environmental protection.
3. The analysis and the interpretation of information about the process.
4. Critical analysis of problems in the field of environmental protection.

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7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1) Introduction to risk assessment Test methods: a vital component of the environmental risk assessment of chemicals	- define risk and explain the categories of risk, the way of expressing risk, the risk assessment procedure and risk management - describe and classify the test methods as a vital component of the environmental risk assessment of chemicals	- define risk - know the categories of risk - know the way of expressing risk - understand what includes risk assessment and risk management - know the standard testing methods of chemical substances used in the assessment of environmental risk - know the purpose, indicators and possible limitations of the testing methods (physico-chemical, biodegradation, bacterial toxicity, aquatic toxicity, soil, sediment and avian toxicity test methods)
2) Application of risk assessment methods to evaluate human health and ecological impacts of chemicals releases to the environment	- define the main factors in making an environmental risk assessment of chemicals and explain the assessment procedure - define and explain the major components of risk assessment to human health from chemicals	- know the procedures of environmental risk assessment according to EU Directives and know the assessment factors: aquatic, STP microorganism, sediment, terrestrial - define the main factors (predicted environmental concentration – PEC and predicted no effect concentration - PNEC) in making an environmental risk assessment of chemicals and show examples of

FORM 2

		calculations - in general describe the procedure of environmental risk assessment of chemicals - know the principles of some EU Directives or international agreements which control directly or indirectly the quantities of specific chemicals or chemical classes which may be used in or discharged to the environment (EQU-Environmental Quality Objectives; BATNEEC-Best Available Techniques not Entailing Excessive Cost, Precautionary principle) - know and understand the tools of the major components of risk assessment to human health from chemicals (hazard assessment, dose-response, exposure assessment, risk characterization)
3. Risk assessment for industrial sites and waste landfills	- Recognise and understand specify the legal requirements for risk control at industrial sites - Adopt the basic elements of major accident hazards control for the Seveso industrial sites - Understand the correlation of waste management activities with specific health and safety, and environmental risks. - Understand and the risk assessment frameworks for	- specify the main goals and requirements of Seveso II directive and their transposition into national legislation - explain the correlation between risk assessment elements and define their role in control of major accident hazards - define hazards according to Seveso II directive and explain the methodology of hazard identification. - demonstrate of the risk matrix and explain the

FORM 2

	household waste landfills - Correlate specific activities and exposure paths with the corresponding risks.	importance of its' application in risk management -list and explain the risk mitigation measures proposed
		within the national Waste management strategy -specify the sources, transportation and exposure paths for landfill gas and leachate with the risk assessment of landfill sites.
4. Qualitative and quantitative methods in risk assessment	- understand the methodology of data collection and analysis within the process of risk assessment - adopt and apply qualitative and quantitative methods in risk assessment process -	- list and explain the categories of scientific evidences i.e. information in risk assessment - demonstrate the application of Bayes' law in quantitative risk assessment - outline and explain the conceptual model of location in risk assessment - specify and describe types of logic trees and their application in risk assessment - outline event/decision tree based on the given example -describe the risk analysis procedure based on fault tree – demonstrate qualitative and quantitative analysis in risk assessment based on the given example using the fault tree

FORM 2

1) Course teacher: Full Prof.Katica Sertić-Bionda, PhD

2) Name of the course: Environmental Protection in Petroleum Refining

3) Study programme (undergraduate, graduate): graduate

4) Status of the course: elective

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. to identify the types of contaminants (aromatic and sulphur compounds) in petroleum refining processes and petroleum products application.

2. to analyse the possibilities of aromatic and sulphur compounds reduction in petroleum refining processes.

3. to distinguish the relevance of petroleum refining processes (catalytic cracking, catalytic reforming) regarding the application and ecological requirements on the products.

4. to select the methods of aromatic and sulphur compounds removing from refinery wastewater streams.

5. to relate the vehicle exhaust emissions with characteristics of fuels.

6) Learning outcomes at the level of the study programme:

1. to apply the advanced knowledge of mathematics, phisics, chemistry and elementary engineering sciences.

2. to recognize and to solve problems regarding environmental protection.

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Environment pollution in petroleum refining processes	- to distinguish the relevance of petroleum refining processes regarding the application and ecological requirements on the products.	- to explain the relevance of given petroleum refining process (catalytic cracking, catalytic reforming) regarding the application and ecological requirements on the products.

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2.Environment pollution in transportation and apllication of petroleum products	- to relate the vehicle exhaust emissions with characteristics of fuels.	-to explain the relation between characteristics of given fuel (motor gasoline, diesel fuel) and vehicle exhaust emissions.

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FORM 2

1) Course teacher: Prof. Zlata Hrnjak-Murgić, PhD

2) Name of the course: Recycling and Waste Management

3) Study programme (undergraduate, graduate): graduate

4) Status of the course: elective

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. acquisition of knowledge and understanding related to the waste generation, pollution, sustainable development

2. acquisition and understanding of knowledge related to life cycle analysis (LCA)

3. acquisition of knowledge regarding the characterization of solid waste (municipal waste) chemical and physical composition of waste

4. understanding and basic knowledge regarding the system for the disposal and recycling of solid waste and utilization of energy from burning and decomposition of waste

5. understanding the technology of recovery of waste, formation of secondary materials, methods for estimating the composition of solid waste

6) Learning outcomes at the level of the study programme:

1. professional knowledge of protecting the local and global environment, the enhancement and management of the environment

2. to be capable of analysis and evaluation of comprehensive waste management technologies

3. a critical analysis of problems in the field of environmental protection

4. forming their own opinion and understanding global processes; process managing and planning

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Introduction to environmental pollution - green engineering	- to define impact of solid waste on the environment -to define type of solid waste: inert, hazardous, industrial… - to adopt the main principles	- to adopt the knowledge of various type of waste - to explain the main postulate of green engineering and sustainable

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	of sustainable development	development
2. Solid waste	- to indicate the life cycle assessment (LCA), an economic analysis of the life cycle (LCC) - to define characterization of municipal solid waste - to indicate the methods for determination of physical and chemical properties of solid waste	- to define life cycle assessment method and explain their importance - to estimate the amount and composition of the solid waste - to distinguish the main methods and properties: density, moisture, energetic value
3. Concept of solid waste management	- to define generation, collection, transport of waste - to define the technologies of waste separation, washing, grinding - secondary raw materials	- to explain the stream of waste, systems build for the transport and collection -to distinguish the main technologies of: separation, washing, grinding - to evaluate the secondary raw materials quality
4. Recycling	- to indicate the technologies processes of recycling, depending on the type of material (glass, paper, metal, building materials, electronic waste, plastic waste)	- to explain each type of technologies for various materials from waste: , paper, metal, building materials, electronic waste, plastic waste, hazardous …
5. Incineration of solid waste	- to indicate the type of waste suitable for incineration and energy recovery - to define the thermodynamics and kinetic of the incineration processes - to define the technological processes for the incineration	-to distinguish and explain the energy value of certain types of materials -to explain the importance of theoretical evaluation of incineration thermodynamics and kinetic -to distinguish the main technologies for the incineration
6. Landfills	- to indicate the terms for the selection of landfill position	- to explain importance and significance of landfill

FORM 2

	- to indicate the components of modern landfills, - to define the formation of landfill gas and landfill leachate - to define the system for control and management of landfill	position - to distinguish the main components of the modern landfills -to define the systems for drainage of water, gas, controlling drinking water, treatment of landfill leachate

FORM 2

1) Course teacher: Prof. Marija Vuković Domanovac, PhD

2) Name of the course: Bioremediation

3) Study programme (undergraduate, graduate): graduate

4) Status of the course: optional

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):	**6) Learning outcomes at the level of the study programme:**
1. to recognize sources and causes of water pollution and soil 2. to define microbiological processes and environmental factors 3. to link economic and environmental factors in the application of process of bioremediation 4. to choose an acceptable process of bioremediation in solving environmental problems	1. to relate the causes and consequences of environmental pollution in the analysis of indicators of the state of the environment 2. to use the methodology of ecological engineering in the development process 3. to apply eco-engineering approach in assessing justifiability of using certain technologies to protect the environment 4. to choose technology with the aim of reducing the negative environmental impacts, and consumption of raw materials and natural resources for sustainable development

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	**Learning outcomes**	**Evaluation criteria**
1. Fundamentals of bioremediation	- to define the process of bioremediation - to explain microbiological processes - to point out advantages and limitations of bioremediation	- explain the essence of the process of bioremediation - recognize microbiological processes depending on the type of environmental pollution - indicate the advantage and limitations of bioremediation
2. The implementation of bioremediation	- to explain *in situ* bioremediation - to explain *ex situ* bioremediation - to point out biostimulation	- indicate technique of *in situ* bioremediation - indicate techniques of *ex situ* bioremediation - indicate effects of

FORM 2

	and bioaugmentation	biostimulation and bioaugmentation in the bioremediation processes
3. Strategy of bioremediation	- to select the optimal environmental conditions of biodegradation and polluted sites	- explain the relationship between process and environmental factors in the process of bioremediation
	- to point out connection between of certain pollutants and microorganisms involved in bioremediation - to explain more effective method of bioremediation implementation	- identify pollutants and isolate microorganisms responsible for bioremediation - indicate the factors important for a more efficient way of implementation of bioremediation
4. Application of bioremediation	- to interpret examples of bioremediation of oil, chlorinated phenols, and nitroaromatic compounds pollution - to give examples of bioremediation of metals, ammonia and nitrate pollution - to interpret phytoremediation and give examples	- propose a method of bioremediation of pollution caused by organic substances - propose a method of bioremediation of pollution caused by inorganic substances - indicate techniques and mechanisms of phytoremediation

FORM 2

1) Course teacher: Vesna Tomašić

2) Name of the course: Catalytic reactors

3) Study programme (undergraduate, graduate): Environmental Engineering (graduate)

4) Status of the course: mandatory (optional)

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. define process variables and parameters of chemical reactors
2. analyze experimental data in order to determine the kinetic model
3. consider the kinetics of reactions in homogeneous and heterogeneous systems
4. identify key variables necessary for the performance of the catalyst
5. explain classification of catalysts according to the structure, function and conditions of their use
6. select the appropriate laboratory reactor to determine the kinetics of catalytic and non-catalytic reactions
7. estimate the values of kinetic model parameters
8. choose the appropriate type reactor with respect to the features of the reaction system, the features of the process, the reaction rate and working conditions

6) Learning outcomes at the level of the study programme:

1. advanced knowledge of mathematics, physics, chemistry and biology
2. advanced knowledge of elementary engineering subjects
3. setting, recognition, formulation and solution to engineering problems, including the balance of matter and energy
4. the conducting of experiments and explaining the data retrieved during the experiment
5. active participation in creative, synthetic and integrative activities related to the ecological and sustainability processes
6. understanding of engineering processes and their design.

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria

FORM 2

Catalysis	- assess the importance of catalytic processes for national economy - compare homogeneous vs. heterogeneous catalysis - consider the basic characteristics of the catalyst - identify key variables necessary for the performance of more active, selective and stable catalyst - recognize the relationship between the structural and chemical properties of the catalyst and its catalytic properties - determine the physical, chemical, mechanical and catalytic properties of the catalyst - identify key variables necessary for the performance of more active, selective and stable catalyst - distinguish kinetic models of reactions in homogeneous and heterogeneous systems - consider differences between macrokinetics and microkinetics - select the appropriate laboratory reactor to determine the kinetics of catalytic reactions	- explain how and why the catalyst affects the reaction rate - explain the basic principles of homogeneous and heterogeneous catalysis - describe and explain the different catalytic processes - analyze and explain the influence of the composition of the catalyst on its activity, selectivity and stability - apply different analytical methods suitable for the characterization of catalysts - develop kinetic models for heterogenous catalytic reactions based on the analysis of the mechanism of the reaction - explain the difference between intrinsic and apparent reaction rate - examine the impact of inter- and intraphase diffusion on the reaction rate - calculate factor of efficiency with respect to inter- and intraphase diffusion - apply appropriate experimental approach or theoretical criterion for estimation of influence of the inter- and intraphase diffusion on the overall reaction rate
Classification of catalytic reactors	- describe an integrated approach to the development of catalysts and reactors - identify factors that influence the choice and performance of the catalytic reactor - analyze and compare the performance of the reactor for given homogeneous and heterogeneous catalytic processes - explain methods for separation of catalyst and reaction products on the example of homogeneous catalytic reactions	- give examples of different designs of reactors that are applied in the system of gas-liquid-solid - compare the general features of the process that is carried out in liquid and gas phase - give examples of industrial catalytic processes which are carried out in multiphase reactors - select the appropriate method of separation of the catalyst with respect to the desired process

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Specific features of the fixed bed reactors	- analyze the performance of catalytic reactors with fixed bed catalyst - explain the advantages and disadvantages of the fixed bed reactor compared to other types of reactors - analyze the working principle of adiabatic reactor - define the conditions for adiabatic operation of the reactor - analyze the flow through a fixed bed reactor - explain the factors that lead to deviations from the ideal flow conditions inside the reactor - interpret the terms of the axial and radial dispersion	- give examples of reactors with fixed bed catalyst - calculate the temperature sensitivity of reaction - give examples of processes that are carried out in adiabatic reactors - describe different versions of adiabatic reactor and the principle of their work - specify the criteria that determine the maximum allowed pressure drop in the reactor
Moving bed reactors	- analyze the basic principle of work of the moving bed reactors - describe the advantages and disadvantages of moving bed reactors - analyze the processes of heat and mass transfer in the suspension reactors - apply appropriate experimental methods and theoretical correlations for assessment of the mass transport limitations on the overall reaction rate in the slurry reactor	- summarize the advantages of the moving bed reactors in relation to other types of reactors - compare the fixed bed reactors and the moving bed reactors with regards to the pressure drop inside the reactor - distinguish and compare different types of suspension reactors and describe how their work

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FORM 2

1) Course teacher: Prof. Marija Vuković Domanovac, PhD
Prof. Felicita Briški, PhD

2) Name of the course: Solid Waste Composting

3) Study programme (undergraduate, graduate): graduate

4) Status of the course: optional

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. to collect the basic knowledge related to the terminology, division and basic data on waste

2. to describe the technology of waste treatment and disposal of solid waste

3. to analyze the characteristics of composting materials, to define process equipment and input and output values of composting process

4. to set up mass and energy balances for a given composting materials and to sketch diagrams of composting process

6) Learning outcomes at the level of the study programme:

1. to use basic professional knowledge in the field of waste management

2. to analyze and estimate an integrated waste management system

3. to analyze, optimize, plan, and manage the composting process

4. to select process equipment with the highest energy efficiency and to assess the economic viability of the overall process

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	**Learning outcomes**	**Evaluation criteria**
1. Introduction to basic data on waste	- to define the types of waste - to define specific categories of waste - to indicate the recovery and/or disposal of waste - to assemble the legislation and planning documents related to the issue of waste management	- distinguish waste according to place of generation and properties - recognize regulations related to special categories of waste - distinguish between material and energy recovery and estimate the possibilities of waste disposal - use of legislation in the field

FORM 2

		of waste management
2. Waste treatment	- to explain the mechanical - biological waste treatment (MBT) - to explain the thermal treatment of waste - to indicate the possibilities of advanced methods of waste treatment - to assemble the legislation and documentation relating to the procedures for the treatment of waste	- interpret basic ways of waste treatment - distinguish physic, chemical and biological processes of waste treatment - explain the criteria for the application of more advanced methods of waste treatment - use of legislation in the field of waste management
3. The purpose and objectives of composting, the choice of substrate and systems for composting, composting factors, microbiology and mechanisms of aeration	- to explain the objectives of composting - to define the potential of selected substrates and select the composting systems - to select the factors affecting composting - to identify types of microorganisms essential for composting - to analyze the mechanisms and explain the importance of optimizing the aeration during composting	- compare aerobic and anaerobic process treatment of solid waste and explain the significance and application of these processes. - explain essential chemical and physical properties of composting materials - compare types of reactor and non-reactor systems - assess the importance of different groups of microorganisms in the composting process - explain the influence of air flow on the process and to sketch the air flow through the composting mass and oxygen transfer in multiphase system
4. Thermodynamics, mass and energy balances in composting process, the selection of process equipment and process control	- to explain the mechanisms of heat transfer and thermal properties of compost - to set up mass and energy balances for selected substrates and systems - to show kinetics of growth of microorganisms and their	- describe mechanisms of heat transfer during the process and select the mathematical expression that describe it - develop a reactor process model - explain empirical kinetic

FORM 2

	inactivation by evolved heat, and to analyze empirical kinetic models - to describe planning and designing the systems for composting - to apply the acquired knowledge in the selection of process equipment	models for the given examples - assess the economic viability of the reactor system - apply mathematical model for higher efficiency of composting process

FORM 2

1) Course teacher: Prof. Zlata Hrnjak-Murgić, PhD

2) Name of the course: Polymer Waste Management

3) Study programme (undergraduate, graduate): graduate

4) Status of the course: elective

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. acquisition, understanding and analyzing the basic knowledge related to the synthesis, chemical composition, structure, production, properties and application of polymer materials
2. acquisition, understanding and analyzing the basic knowledge related to the technology of recycling polymer materials, incineration and biodegradation
3. acquisition of the ability to understand the methods of process control and quality control of recycled products
4. ability to work independently in chemical and physical laboratory
5. ability of self presentation and interpretation of laboratory results in written and oral form

6) Learning outcomes at the level of the study programme:

1. to use basic professional knowledge in the field of waste management

2. to analyze and estimate an integrated waste management system

3. knowledge of various kinds of materials and technologies for their recycling

4. the ability to create solutions and independently solve problems (including the identification and formulation of the problem) in materials science and engineering

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	**Learning outcomes**	**Evaluation criteria**
1. Introduction to polymer chemistry	- to indicate the basic terms of polymer chemistry : monomers, polymers, macromolecules, - to acquire knowledge about the polymer synthesis processes	- to define the basic terms in polymer chemistry - distinguish the synthesis processes to obtain different type of polymers
2. Polymer waste stream, advantages and disadvantages	- acquisition of knowledge and understanding of the	-distinguish the type of polymer waste

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of polymer materials	types of polymeric materials in the application, their collection, the pretreatment processes, secondary raw materials for recycling	- indicate the procedures and processes of polymer pretreatment: collection / sorting-separation / shredding / washing -to define the hazardous waste in polymeric materials
3. Recycling of polymeric materials	-to indicate the different technological processes for polymer recycling -to explain the properties and quality control of recyclate	- to distinguish the technological processes for plastics recycling - to indicate the properties of the recycled polymers and products
4. Recycling of polymeric materials	- acquisition of knowledge and understanding about the mechanical recycling of polymer waste	- to define mechanical recycling - extrusion, injection / molding / recycling of heterogeneous polymer waste, recycling and accessories for quality control
5. Recycling of polymeric materials	- acquisition of knowledge and understanding about the chemical recycling of polymer waste	- to define chemical recycling - hydrolysis / gasification / hydrating / pyrolysis
6. Incineration - energy recovery and rubber recycling	- acquisition of knowledge and understanding about the energy recovery of polymer waste - to indicate rubber recycling	- to define stoichiometric ratio of plastic waste for combustion - to explain the energetic value of various types of plastic waste - to define combustion technological processes - to define recycling rubber and tires -mechanical / chemical recycling

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FORM 2

1) Course teacher: Krešimir Košutić (Full Professor)

2) Name of the course: Membrane technology of water treatment

3) Study programme (undergraduate, graduate): The graduate study of Environmental engineering and Applied chemistry

4) Status of the course: optional

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):	**6) Learning outcomes at the level of the study programme:**
-Knowledge of materials for membrane preparation, preparation methods and the methods of characterization - Classify membrane processes according to the driving force, - Knowledge of membrane systems design - Define mass transfer through the membrane, flux, define separation mechanisms - Knowledge of the application of membrane technology in the water treatment: microfiltration, ultrafiltration, nanofiltration and reverse osmosis, HERO processes, electrodialysis - Prepare and make laboratory experiments, analyze and interpret the results of experiments - Prepare laboratory reports - Get acquainted with the industrial RO desalination plant of brackish water through field-education	1. advanced knowledge of mathematics, physics, chemistry and biology; 2. advanced knowledge of elementary engineering subjects; 3. professional knowledge of protecting the local and global environment, the enhancement and management of the environment, the legislation related to the protection of the environment; 4. professional knowledge from the field of water, air and ground management, waste and energy management; 5. independence and reliability in independent work; 6. efficiency, reliability and adaptability in team work; 7. the conducting of experiments and explaining the data retrieved during the experiment; 8. active participation in creative, synthetic and integrative activities related to the ecological and sustainability processes; 9. understanding of engineering processes and their design

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7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1.-2.The membrane; Membrane processes; membrane modules	- Define the concept of membranes, knowledge of various kinds materials for preparation membranes and membrane classify, - Define performance membranes, their selectivity and other physical and chemical characteristics - Classification of membrane operations by the driving force - Classify basic types of membrane modules that are applied in practice, recognize their strengths and weaknesses	Explain membrane processes in terms of the membrane, feed, retentate, permeate List types of industrial membrane processes Discuss membrane shapes and membrane modules
3.-6. Membrane systems-design	- Define dead-end and cross-flow - Describe single and multi-stage process, and batch system for smaller applications - Define dead-end and hybrid / cross-systems - Identify advantages cascading operations	Explain use of dead-end and crosss-flow membrane operation Explain use and advantages/disadvantages of cascades operations Calculate and estimate of conversion in spiral modul
7.-8. Mass transfer through the membrane, mass transport models	- Define and describe the mass transfer through the membrane (water transport, salt transport, specific flux) - Define the principles of retention and separation mechanism -Describe and distinguish of concentration polarization and membrane fouling-causes and ways of preventing in	Explain mass transfer of water and salt through membrane List membrane separation mechanism Explain concentration plarization List and explain causes of membrane fouling

FORM 2

	practice - Explain membrane permeation- permeation of gas, gas diffusion, pervaporation, membrane distillation -list and describe the electrical membrane processes (electrodialysis, membrane electrolysis, bipolar membrane) - Prepare and make a laboratory exercise RO / NF separation saline solution, processing and analysis of measurement data, and write a lab report	
9.-13. Pressure membrane processes: microfiltration, ultrafiltration, nanofiltration reverse osmosis, HERO process	- Describe the application of membrane processes MF, UF, NF and RO in water tretment - argue application: the case of industrial obtaining drinking water from the sea, from brackish water, getting ultrapure water	Explain osmosis and how reverse osmosis can be achived Differentiate between the asymmetric and thin layer composite membranes, and between microporous and dense membranes Explain desalination of sea and brackish water by reverse osmosis and nanofiltration
14. Electric membrane processes	-be able to describe principles of electrodialysis; membrane electrolysis, bipolar membranes and fuel cells	Expalin structure of cationic and anionic ion exchange membranes Explain mass transfer in dialysis and electrodialysis

FORM 2

1) Course teacher: Full Prof. Ante Jukić, PhD, Assoc. Prof. Elvira Vidović, PhD

2) Name of the course: Environmental Protection in Petrochemical Industry

3) Study programme (undergraduate, graduate): graduate

4) Status of the course: elected

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. to distinguish the procedure of conversion of fossil (petroleum and gas) and renewable raw materials into a spectrum of chemicals and materials.

2. to outline the reactions schemes and chemical mechanisms; to differentiate the technological solutions characteristic for petrochemical industry.

3. to explain the concept of a conjoint approach to the environment protection by BAT for concrete examples

4. to analyze the advantage and disadvantage of the clean fuel production and hydrogen based economy.

5. to describe consequences of integration of petroleum refining and petrochemical industry regarding the reduction of environmental impact

6) Learning outcomes at the level of the study programme:

1. professional knowledge of protecting the local and global environment, the enhancement and management of the environment, the legislation related to the protection of the environment

2. recognition and finding solutions to problems regarding environmental protection

3. understanding of engineering processes and their design

4. dedication to professional ethics and responsibility towards the norms of the engineering practice

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. The significance of petrochemical industry and its influence on the environment	- to analyze petrochemical industry regarding: row materials (petroleum, natural gas, coal, biomass), processes and products-technological, economical, ecological,	- to explain the importance and structure of petrochemical industry and its influence on the modern everyday life

FORM 2

	social and geopolitical aspects	
2. Application of BAT concept on industrial production of ammonia	- to explain the advantages and disadvantages of given processes including application of BAT	- to assess the process regarding the ecological, technological and economical view

FORM 2

1) Course teacher: Helena Otmačić Ćurković

2) Name of the course: Corrosion and environment

3) Study programme (undergraduate, graduate):graduate

4) Status of the course:

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. identify hazards that corrosion and inadequate corrosion protection present to environment and human health;
2. identify how some of the corrosion protection methods may endanger environment and human health due to the release of toxic compounds;
3. estimate which corrosion protection method is the most adequate for given corrosion issue;
4. relate presence of pollution and climatic parameters to the corrosion level of various structural materials.

6) Learning outcomes at the level of the study programme:

1. advanced knowledge of corrosion engineering
2. professional knowledge of protecting the local and global environment,
3. recognition and finding solutions to problems regarding environmental protection;
4. conducting of experiments and explaining the data retrieved during the experiment;

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	**Learning outcomes**	**Evaluation criteria**
1. Environment pollution	- indentify common sources of pollution -discuss different approaches towards reduction of pollution caused by industry	- student should indentify the most common sources of pollution -student should explain the principles of sustainable development
2. Corrosion processes	-explain causes of corrosion -distinguish various types of corrosion processes	- identify causes of corrosion and possible type of corrosion that will occur for specific material in given environment.

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		-write corrosion reactions for selected combination metal-environment
3. Harmful substances released to environment due to the corrosion or in corrosion protection	-explain which harmful substances can be released to environment due to the corrosion or in corrosion protection - explain the influence on environment and human health of the most common pollutants related to the corrosion processes	-name harmful compound that can be released from particular construction or process related to corrosion protection and explain its influence on environment and human health
4. Corrosion damage	-analyze the importance of corrosion protection for safe operation of various industrial processes and stability of metallic constructions, - identify the critical parts of metallic constructions or technological processes where inadequate corrosion protection may cause serious damage	-explain the causes of known corrosion failure -experimentally determine the corrosion rate of metallic materials used in medicine as implants.
5. Influence of environment parameters on corrosion type and rate	-correlate changes in environment with corrosion stability of metallic materials - relate presence of pollution and climatic parameters to the corrosion level of various structural materials	- explain key factors that lead to damage of cultural heritage and other constructions in polluted environment - experimentally determine corrosion rate of bronze in different environments
6. Corrosion protection methods	- identify potential hazards of application of various corrosion protection methods -explain which modifications in existing corrosion protection methods are	-explain potential hazards of some corrosion protection method and how they can be overcome

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	needed to comply with recent environmental regulation	

FORM 2

1) Course teacher: Prof. dr. sc. Đurđa Vasić-Rački

Assoc. prof. dr. sc. Zvjezdana Findrik Blažević

2) Name of the course: Environmental engineering project

3) Study programme (undergraduate, graduate): graduate

4) Status of the course: obligatory

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. To define the theoretical background of process plant design.

2. To apply the principles of mass and energy conservation laws on the project assignment.

3. To sketch the process scheme and specify process units and flows.

4. To write a mathematical model of the chemical or physical process in the project assignment on the basis of input data.

5. To simulate the example in the project assignment by using the programme packagge SuperPro Designer..

6. To design the process units by using SuperPro Designer.

7. To optimize the process considering the oputput values.

6) Learning outcomes at the level of the study programme:

1. Analysis and optimization of process plant by using the computer program

2. Application of chemical engineering methodology on the development of environmentally friendly process.

3. Application of computer program, and computer techniques in general in modeling and process optimization.

4. Recognition and finding solutions to problems regarding environmental protection.

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Basics terms in process design. Project organization.	- to define and explain the roles of investors and designer - to define the factors that affect the choice of process plant location - to define the phases in project realization	- explain the roles of investor and designer - explain how the process plant location is chosen - number and describe the phases of project realization
2. Contracts – regulation of relationship between the investor	- to define the types of contracts	- distinction and recognition of advantages and disadvantages of

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and designer	between investor and designer - to define the advantages and	types of contract between investor and designer
	disadvantages of each contract type	
3. Research and process development. Process development phases.	- to explain the role of chemical engineer in process development - to define the possibilities of technological process development - to define the phases of process development - to discuss technical problems of scalue up	- explain the role of chemical engineer in process development - number the phases of process development and the possibilities of technological process development - explain the problems with process scale up
4. Process rating. Feasibility study of the process. Production costs differentiation. Financial effect of investment	- to define the expenses of the process development - to define the cumulative money flow during investment	- number and explain the types of expenses in process development
5. Project assignment. Process schemes. Block schemes. Process flow scheme.	- to define the important features of process assignment - to define the types of process schemes - to summarize and apply the accumulated knowledge during studies on project assignment	- to define the project assignment and process scheme on the basis of given example - use the mathematical model to describe the given process and incorporate it in the project - optimization of the given process by using the program SuperPro Designer
6. Pipes and instrumetation. Process control and instrumentation. Process safety.	- to define P&I diagram - to define and explain the features that affect the process safety	- explain the significance of P&I diagram - explain the important features for process safety
7. Detail process design. Project programme. Plant schedule.	- to define the contents of project program - to define and explain the important steps in the schedule of process plant	- explain the important facts for detail process design - explain the way to determine the schedule of process units in process plant
8. Auxiliaries and objects. Environmental assessment.	- to define the auxiliaries and objects neccessary in the process plant - to define and explain the environmental assessment study	- number the auxiliaries and objects necessary in the process plant - explain the legal basis of environmental assessment and explain what it means

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FORM 2

1) Course teachers: Assoc. prof. dr. sc. Zvjezdana Findrik Blažević, Assoc. prof. dr. sc. Ana Vrsalović Presečki

2) Name of the course: Bioreaction technique

3) Study programme (undergraduate, graduate): graduate

4) Status of the course: optional

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. To distinguish homogeneous and heterogeneous biocatalysis
2. To distinguish heterogeneous biocatalysts according to the method of their preparation
3. To define basic parameters that characterize immobilized biocatalyst
4. To estimate the values of kinetic parameters of the complex enzymatic system from the experimental data
5. To develop mathematical model for the complex enzymatic system (multienzyme), as well as for the process catalyzed by whole cells as biocatalyst in different types of reactors
6. To simulate the process in different types of reactor at different initial process conditions
7. To carry out the biotransformation catalyzed by purifies enzyme and permeabilized whole microorganism cells
8. To define the methods of bioproduct separation

6) Learning outcomes at the level of the study programme:

1. Application of chemical engineering methodology in development of mathematical models for complex reaction systems
2. Applications of mathematical methods and computer techniques for evaluation of model parameters and process simulation
3. Optimization of reaction system (initial process conditions) by using the mathematical model
4. Gaining practical experience in collecting experimental data in the lab

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Methods of preparation of heterogeneous biocatalysts	- to define the methods of preparation of heterogeneous biocatalyst - to define and explain advantages and disadvantages of each method of immobilization	- making the difference between homogeneous and hetergeneous catalysis - to recognize the advantages and disadvantages of heterogeneous biocatalysts

FORM 2

	- to define and explain the differences between immobilized enzymes and whole cells - to define different factors that influence the choice of biocatalyst immobilization method	- evaluation of the application are of immobilized enzymes and immobilized whole cells
2. Characterization of immobilized biocatalyst	- to define reaction engineering parameters of heterogeneous biocatalysts and discuss the methods of their determination - to define the methods of determination of the activity of immobilized biocatalyst - to define the effectiveness of immobilized biocatalyst - to define Thiele modulus	- numbering the limitation of the use of immobilized biocatalysts - ability to assesss wether the process is diffusion limited on the basis of experimental data - ability to determine the activity of immobilized biocatalyst from the experimental data
3. The application of immobilized biocatalysts	- to discuss the application of heterogeneous biocatalysts and immobilized proteins in general	- ability to discuss the importance of immobilized proteins
4. Biocatalysts in non-conventional media	- to define the non-conventional media used in biotransformations - to define the advantages and disadvantages of the use of non-conventional media	- recognition of purpose of different reaction media and importance of the choice
5. Stability and deactivation of biocatalysts	- to discuss the types of biocatalyst stability - to discuss the methods of determination of operational stability	- ability to determine of operational stability of biocatalyst from the experimental data - ability to estimate the biocatalyst deactivation constants from the experimental data and its incorporation in the kinetic model of the process
6. Mathematical modeling of complex enzymatic systems with coenzyme regeneration	- to develop and solve the mathematical model for multi-enzyme reaction system in different reactor types - to evaluate and apply the developed mathematical model and predict the process outcome	- ability to develop and apply the mathematical for simulation and optimization of the reaction system

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	by its use - to select the optimal conditions of the process by using the mathematical model	
7. Bioprocesses catalyzed by whole cells	- to identify the products of the process catalyzed by whole cells - to define the conditions of cell growth - to define and explain the characteristics of cell methabolism - to number the methods of metabolism regulation	- ability to determine the possibility of production of certain product by using whole cells
8. Mathematical modeling of biomass growth	- to explain the kinetic model of microbial growth - to explain the kinetic model of substrate consumption - to explain the kinetic model of product synthesis - to evaluate the process efficiency	- ability to estimate kinetic parameters of the process - ability to develop model of microbial growth in different types of reactor - ability to determine the yield, substrate conversion, space-time yield
9. Types of bioreactors and bioprocess methods for microbial growth	- to define the types of bioreactor - to define the aeration - to define the types of mixing - to distinguish the types of bioprocess methods for microbial growth - to define the methods for bioprocess monitoring	- ability to determine the optimal bioreactor type for a single process - to estimate the volume coefficient of oxygen transfer - ability to determine the optimal type of mixing in bioreactor for specific process - ability to determine the type of bioprocess implementation
10. Bioproduct separation processes	- to define the methods of cell separation - to define the methods for separation of products from the cell - to define the methods of purification and concentration of bioproducts	- ability to determine the optimal way of product separation

FORM 2

FORM 2

1) Course teacher: Prof. Sanja Papić, PhD

2) Name of the course: Organic dyes and environment protection

3) Study programme (undergraduate, graduate): graduate

4) Status of the course: elective course

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1.Explain the basic concepts of color and correlations between the chemical structure of organic compounds and their color (coloration theory)
2.State the areas of application and classification of organic dyes
3.Describe the processes of production of selected organic dyes
4. Identify the parameters that determine the emission of dyes in the environment
5.Explain the problems of the presence organic dyes in the environment and predict the possible solutions
6.State the ecological and toxicological aspects of dyes
7. List the factors of impact assessment of dyes on human health and the environment
8.Explain the principles of responsible care essential for the sustainable development of organic dye industry

6) Learning outcomes at the level of the study programme:

1. Basic professional knowledge of water management, soil, air and waste
2.Critical analysis of problems in the field of environmental protection
3. Problem solving in the field of environmental protection

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria
1. Organic synthetic dyes	-explain the basic concepts of color and correlations between the chemical structure of organic compounds and their color (coloration theory) -state the areas of application	-define the basic concepts of color -explain the coloration theory - know the classification of dyes - list the chemical and the

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	and classification of organic dyes -describe the processes of production of selected organic dyes	application groups of dyes - know the application fields of organic synthetic dyes - know the method of production (synthesis) of selected dyes from important chemical classes
2.Ecological and toxicological aspects of organic synthetic dyes	-identify the parameters that determine the emission of dyes in the environment -explain the problems of the presence organic dyes in the environment and predict the possible solutions -state the ecological and toxicological aspects of dyes -list the factors of impact assessment of dyes on human health and the environment	-know the sources of environmental pollution with dyes -know the parameters that determine the emission of dyes in the environment - explain the problems of the presence organic dyes in the environment and predict the possible solutions -know the ecological and toxicological aspects of dyes - know about the problem in occupational exposure to dyes - know what data containing Safety Data Sheet for dyes -know the requirements for food dyes -know the factors of impact assessment of dyes on human health and the environment - specify a key legislation for dyes
3. The principles of responsible care in the industry of organic dyes and pigments	-explain the principles of responsible care essential for the sustainable development of the organic dyes industry	- know the principles of responsible care - know about the activities of ETAD (Ecological and Toxicological Association of Organic Dyes and Pigments Manufacturers) in the protection of health and the environment during production, transport, use and

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		disposal of organic dyes; and ETAD contribution to sustainable development.

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FORM 2

1) Course teacher: Prof. Sanja Papić, PhD
Prof. Ana Lončarić Božić, PhD,
Assistant professor Hrvoje Kušić, PhD

2) Name of the course: Advanced Oxidation Technologies

3) Study programme (undergraduate, graduate): graduate

4) Status of the course: elective

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. Define and classify the advanced oxidation processes; describe their role in the environment protection; identify their advantages and possible disadvantages in water/wastewater treatment

2. Explain the characteristics of OH radicals and mechanisms of degradation of organic compounds by radical species.

3. Describe the reacting systems, explain the impact of process parameters and discuss the application characteristics of different types of advanced oxidation processes.
4 the ability to understand theoretical background and to apply photo-AOTs
5. the ability correlated the semiconductor structure with their photocatalytic properties in photo-AOTs
6. the ability to understand theoretical background and to apply US based AOTs
7. the ability to correlate basic principles of water radiolysis and high-voltage electrical discharge processes with their application characteristics in water treatment technologies

6) Learning outcomes at the level of the study programme:

1. Basic professional knowledge in the field of application of advanced oxidation technologies for water treatment
2. Ability to analyze and optimize the technology of water treatment based on advanced oxidation processes
3. Gathering and interpreting information about the process
4. Problem solving in the field of water protection by applying the methodology of analytical procedures and methodologies of chemical engineering

7) Teaching units with the corresponding learning outcomes and evaluation

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criteria		
Teaching unit	**Learning outcomes**	**Evaluation criteria**
Introduction, Chemical advanced oxidation processes	- define and classify the advanced oxidation processes; describe their role in the environment protection; identify their advantages and possible disadvantages in water/wastewater treatment -explain the characteristics of OH radicals and mechanisms of degradation of organic compounds by radical species -describe the reacting systems, explain the impact of process parameters and discuss the application characteristics of different types of advanced oxidation processes	- know the types of AOPs, their application and advantages in comparison to conventional water treatment processes -explain the direct and indirect mechanism of oxidation of organic compounds by ozone - know the chemical reactions, reaction mechanism, impact of process parameters, reactor systems and application characteristics (for homogeneous and heterogeneous Fenton type processes, ozonation, catalytic ozonation and peroxone process) -explain the enhancement of effectiveness of chemical advanced oxidation processes by applying UV irradiation. - give an example of research kinetics of degradation of selected organic pollutant in water/wastewater by advanced oxidation

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2. Photochemical and Photocatalytic advanced oxidation processes	- understand the theoretical background and mechanisms involved in photo-AOTs; direct photolysis, UV/H_2O_2 and UV/TiO_2 - understand the influence of key process parameters on degradation efficiency of water pollutants - correlate the semiconductor structure with their role in photocatalytic AOTs	- explain the relationship between energy and irradiation wavelength - demostrate the application of Lambert-Beer's, I and II photochemistry laws to describe processes of direct photolysis - outline chemical equations describing degradation mechanisms of organics in water by UV, UV/H_2O_2 i UV/TiO_2 processes - specify the key process parameters and their influence on process effectiveness - describe phenomena of electron-hole generation and related mechanisms within photocatalytic AOTs - list the main characteristics and explain the advantages and shortcomings of different photo-AOTs
3. Mechanical and electrical advanced oxidation processes	- understand the theoretical background of ultra sound (US) processes within AOTs -correlate the theoretical background of water radiolysis and high-voltage electrical discharge processes with their application characteristics in water treatment technologies	-describe and explain the cavitation mechanism -outline main chemical reactions in US AOTs for water treatment -explain high-voltage electrical discharge phenomena -outline configurations of Corona discharge rectors - describe mechanisms of water radiolysis -describe examples of practical application of radiolysis and high-voltage electrical discharge processes for water treatment

FORM 2

1) Course teacher: Prof. Zlata Hrnjak-Murgić, PhD

2) Name of the course: Polymer Science and Technology

3) Study programme (undergraduate, graduate): graduate

4) Status of the course: elective

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):	**6) Learning outcomes at the level of the study programme:**
1. to collect the basic knowledge about main polymerization reactions 2. to describe and understand the the types of homogeneous and heterogeneous polymerization processes 3. to understand the relationship structure – properties of polymer materials 4. to learn important technologies for polymer processing 5. to understand the knowledge related the polymer degradation and stability 6. to describe and understand the biopolymers	1. application of scientific principles underlying chemistry and chemical engineering on materials, their structure, properties, processing and performance 2. ability to function effectively as an individual or as a member of a multi-disciplinary team, and to present the work in both written and oral form; 3. skills necessary for running chemical and physical laboratories, selection and preparation of adequate laboratory equipment and organization of laboratory work according to standards; 4. an introductionary knowledge to advanced materials and technologies

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	**Learning outcomes**	**Evaluation criteria**
1. The main polymerization reactions	- to define mechanisms of polymerizations: chain, step, ionic polymerisation - to define the main types of synthesized polymers (polyolefines, polyesters, polyamides..) - acquisition of knowledge and understanding influence of catalysts type, temperature and time on formation of	-to interpret polymerization processes -to distinguish different type of polymerizations -to recognize the type of condition and type of structure that is formed

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	polymer chain structure and of molecular weight	
2. The homogeneous and heterogeneous polymerization processes	- to indicate the type of polymerizations: in bulk, in solution, emulsion, suspension… - to indicate the different reactors for polymerizations	-to define the polymerization types: advantages and disadvantages - to explain the differences between the reactors
3. the relationship structure – properties of polymer materials	- to explain the importance of the structure – properties relationship - to indicate the importance of creating a different structure of polymer chain	- to define and explain properties of polymers in relations with applications -to distinguish the importance of different polymer chain structures
4. Technologies for polymer processing	- to indicate basic type of polymer processing technologies: extrusion, injection, pressing, blowing… - to indicate the main equipment and conditions for polymer processing	-to define type of polymer processing -to define main processing equipment for polymers - to explain effect of conditions of production on the properties
5. Polymer degradation and stability	- to indicate the properties of polymer materials - acquisition of knowledge about the main types of polymer degradation and their mechanism - to indicate the mechanism of stabilization processes	-to define various properties of polymer: chemical properties, mechanical, physical … - to define degradation processes of polymers: photodegradation, thermodegradation, oxidative degradation… - to explain the importance of polymer stabilization
6. Biopolymers	- acquisition of knowledge about biopolymers -to indicate biodegradation processes	-to define biopolymers and biodegradation - to explain sustainable development: advantages and disadvantages of biopolymers

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FORM 2

1) Course teacher: Vesna Tomašić

2) Name of the course: Catalytic reactors

3) Study programme (undergraduate, graduate): Environmental Engineering (graduate)

4) Status of the course: mandatory (optional)

5) Expected learning outcomes at the level of the course (4-10 learning outcomes):

1. define process variables and parameters of chemical reactors
2. analyze experimental data in order to determine the kinetic model
3. consider the kinetics of reactions in homogeneous and heterogeneous systems
4. identify key variables necessary for the performance of the catalyst
5. explain classification of catalysts according to the structure, function and conditions of their use
6. select the appropriate laboratory reactor to determine the kinetics of catalytic and non-catalytic reactions
7. estimate the values of kinetic model parameters
8. choose the appropriate type reactor with respect to the features of the reaction system, the features of the process, the reaction rate and working conditions

6) Learning outcomes at the level of the study programme:

1. advanced knowledge of mathematics, physics, chemistry and biology
2. advanced knowledge of elementary engineering subjects
3. setting, recognition, formulation and solution to engineering problems, including the balance of matter and energy
4. the conducting of experiments and explaining the data retrieved during the experiment
5. active participation in creative, synthetic and integrative activities related to the ecological and sustainability processes
6. understanding of engineering processes and their design.

7) Teaching units with the corresponding learning outcomes and evaluation criteria

Teaching unit	Learning outcomes	Evaluation criteria

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Catalysis	- assess the importance of catalytic processes for national economy - compare homogeneous vs. heterogeneous catalysis - consider the basic characteristics of the catalyst - identify key variables necessary for the performance of more active, selective and stable catalyst - recognize the relationship between the structural and chemical properties of the catalyst and its catalytic properties - determine the physical, chemical, mechanical and catalytic properties of the catalyst - identify key variables necessary for the performance of more active, selective and stable catalyst - distinguish kinetic models of reactions in homogeneous and heterogeneous systems - consider differences between macrokinetics and microkinetics - select the appropriate laboratory reactor to determine the kinetics of catalytic reactions	- explain how and why the catalyst affects the reaction rate - explain the basic principles of homogeneous and heterogeneous catalysis - describe and explain the different catalytic processes - analyze and explain the influence of the composition of the catalyst on its activity, selectivity and stability - apply different analytical methods suitable for the characterization of catalysts - develop kinetic models for heterogenous catalytic reactions based on the analysis of the mechanism of the reaction - explain the difference between intrinsic and apparent reaction rate - examine the impact of inter- and intraphase diffusion on the reaction rate - calculate factor of efficiency with respect to inter- and intraphase diffusion - apply appropriate experimental approach or theoretical criterion for estimation of influence of the inter- and intraphase diffusion on the overall reaction rate
Classification of catalytic reactors	- describe an integrated approach to the development of catalysts and reactors - identify factors that influence the choice and performance of the catalytic reactor - analyze and compare the performance of the reactor for given homogeneous and heterogeneous catalytic processes - explain methods for separation of catalyst and reaction products on the example of homogeneous catalytic reactions	- give examples of different designs of reactors that are applied in the system of gas-liquid-solid - compare the general features of the process that is carried out in liquid and gas phase - give examples of industrial catalytic processes which are carried out in multiphase reactors - select the appropriate method of separation of the catalyst with respect to the desired process

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Specific features of the fixed bed reactors	- analyze the performance of catalytic reactors with fixed bed catalyst - explain the advantages and disadvantages of the fixed bed reactor compared to other types of reactors - analyze the working principle of adiabatic reactor - define the conditions for adiabatic operation of the reactor - analyze the flow through a fixed bed reactor - explain the factors that lead to deviations from the ideal flow conditions inside the reactor - interpret the terms of the axial and radial dispersion	- give examples of reactors with fixed bed catalyst - calculate the temperature sensitivity of reaction - give examples of processes that are carried out in adiabatic reactors - describe different versions of adiabatic reactor and the principle of their work - specify the criteria that determine the maximum allowed pressure drop in the reactor
Moving bed reactors	- analyze the basic principle of work of the moving bed reactors - describe the advantages and disadvantages of moving bed reactors - analyze the processes of heat and mass transfer in the suspension reactors - apply appropriate experimental methods and theoretical correlations for assessment of the mass transport limitations on the overall reaction rate in the slurry reactor	- summarize the advantages of the moving bed reactors in relation to other types of reactors - compare the fixed bed reactors and the moving bed reactors with regards to the pressure drop inside the reactor - distinguish and compare different types of suspension reactors and describe how their work