Zał. Nr 1 do ZW 78/2023

# PROGRAM OF STUDIES

FACULTY: **CHEMISTRY**
MAIN FIELD OF STUDY: **Chemical Engineering and Technology**
BRANCH OF SCIENCE: **engineering and technology**
DISCIPLINES: **D1 chemical engineering**
EDUCATION LEVEL: **second-level studies**
FORM OF STUDIES: **full-time studies (3-semester)**
PROFILE: **general academic**
LANGUAGE OF STUDY: **English**

Content:



Resolution no. … of the Senate of Wroclaw University of Science and Technology

In effect since **2024/2025**

**Zał. Nr 2 do ZW 78/2023**
**Attachment no. 1. to the Program of Studies**

# ASSUMED LEARNING OUTCOMES

**FACULTY:** **CHEMISTRY**
**MAIN FIELD OF STUDY:** **CHEMICAL ENGINEERING AND TECHNOLOGY**
**EDUCATION LEVEL:** **second-level studies**
**PROFILE:** **general academic**

Location of the main-field-of study:

Branch of science: **ENGINEERING AND TECHNOLOGY**

Discipline: **CHEMICAL ENGINEERING**

Explanation of the markings:
**Reference to PRK characteristics:**
**P7U** – universal first-degree characteristics corresponding to education at the second-level studies - 7 PRK level
**P7S** – second degree characteristics corresponding to education at the second-level studies - 7 PRK level

after the underscore:
**W** – category "knowledge" (extension: G = depth and scope, K = context),
**U** – category "skills" (extension: W = use of knowledge, K = communication, O = work organization, U = learning),
**K** – category "social competences" (extension: K = critical assessment, O = responsibility, R = professional role),
**INŻ** – learning outcomes leading to obtaining engineering competences.

**Symbols of main field of study learning outcomes at the second cycle of studies for the Chemical Engineering and Technology (ce)**
before the underscore:
**K** – directional learning outcomes,
**2** – second cycle of studies
**A** – general academic profile
**ce** – direction code,
after the underscore:
**W** – knowledge category, **U** – skills category, **K** – social competence category

| Main field of study learning outcomes | Description of learning outcomes for the main-field-of study **CHEMICAL ENGINEERING AND TECHNOLOGY** After completion of studies, the graduate: | Reference to PRK characteristics | | |
|---|---|---|---|---|
| | | Universal first degree characteristics (U) | Second degree characteristics typical for qualifications obtained in higher education (S) | |
| | | | Characteristics for qualifications on 7 levels of PRK | Characteristics for qualifications on 6 and 7 levels of PRK, enabling acquiring engineering competences |
| **KNOWLEDGE (W)** | | | | |
| K2Ace_W01 | has in-depth knowledge of materials, apparatus and devices used in chemical processes on various scales | P7U_W | P7S_WG | P7S_WG_INŻ |
| K2Ace_W02 | knows methods of estimating investment and operating costs of industrial installations | P7U_W | P7S_WG | P7S_WG_INŻ |
| K2Ace_W03 | has extended mathematical knowledge and knows extensive tools for designing and optimizing chemical processes at various scales | P7U_W | P7S_WG | P7S_WG_INŻ |
| K2Ace_W04 | has knowledge of creating and implementing an industrial project | P7U_W | P7S_WG | P7S_WG_INŻ |
| K2Ace_W05 | has in-depth knowledge in the field of creation (design), process optimization and/or design and application of diagnostic/measuring devices | P7U_W | P7S_WG | P7S_WG_INŻ |
| K2Ace_W06 | has in-depth knowledge of development trends and new achievements in the field of chemical engineering and technology; is able to assess the usefulness and possibility of using new achievements in the discipline of chemical engineering | P7U_W | P7S_WG | P7S_WG_INŻ |
| K2Ace_W07 | knows the basic concepts of entrepreneurship and the functioning of an enterprise, including a chemical or biotechnological plant | P7U_W | P7S_WK | P7S_WK_INŻ |
| K2Ace_W08 | has structured and theoretically based knowledge in the production of chemicals, polymers and specialized materials, understanding their role in the civilization development | P7U_W | P7S_WG | P7S_WG_INŻ |
| K2Ace_W09 | knows and understands in-depth issues including sustainable processes in chemical engineering and technology, the role of green chemistry in the development of the chemical industry | P7U_W | P7S_WG | P7S_WG_INŻ |
| K2Ace_W10 | understands the impact of chemical processes on the environment and knows in-depth environmental protection methods/techniques/ technologies in industry | P7U_W | P7S_WG | P7S_WG_INŻ |

| | | | | |
|---|---|---|---|---|
| K2Ace_W11 | understands the economic, legal and ethical conditions of professional activity in applied chemistry, engineering and technical technology, including technical safety and industrial threats | P7U_W | P7S_WK | P7S_WK_INŻ |
| **SKILLS (U)** | | | | |
| K2Ace_U01 | can use mathematical tools to analyze data | P7U_U | P7S_UW | |
| K2Ace_U02 | is able to carry out chemical processes of various degrees of complexity (integration) on laboratory equipment and on a larger scale | P7U_U | P7S_UW | P7S_UW_INŻ |
| K2Ace_U03 | is able to assess the efficiency and quality of products using appropriate physical, physicochemical and chemical methods, including advanced instrumental methods | P7U_U | P7S_UW | |
| K2Ace_U04 | can use analytical methods and simulation programs to solve complex tasks in the field of chemical processes carried out on various scales | P7U_U | P7S_UW | P7S_UW_INŻ |
| K2Ace_U05 | can design a system integrating various unit processes and justify the economics | P7U_U | P7S_UW | P7S_UW_INŻ |
| K2Ace_U06 | can efficiently use modern IT tools for solving engineering tasks and problems; can use advanced computer software to model chemical processes or materials used in them | P7U_U | P7S_UW | P7S_UW_INŻ |
| K2Ace_U07 | can propose and describe the process of synthesizing chemicals and/or materials, also using biocomponents | P7U_U | P7S_UW | P7S_UW_INŻ |
| K2Ace_U08 | acquires, critically evaluates and creatively processes information from scientific literature, databases and other properly selected sources in the field of advanced chemical engineering and innovative chemical technologies | P7U_U | P7S_UW<br>P7S_UU | |
| K2Ace_U09 | uses acquired knowledge from related fields of science and scientific disciplines in formulating and solving complex and unusual problems in chemical engineering and technology | P7U_U | P7S_UW | P7S_UW_INŻ |
| K2Ace_U10 | demonstrates the ability to work in a team, taking on various roles (including leading) | P7U_U | P7S_UK<br>P7S_UO | |
| K2Ace_U11 | is able to independently plan and implement continuous own education in the field of chemical engineering and related sciences; is able to pass on his knowledge to others | P7U_U | P7S_UU | |
| K2Ace_U12 | can use a foreign language at level B2+ of the Common European Framework of Reference for Languages | P7U_U | P7S_UK | |
| K2Ace_U13 | is able to plan and carry out laboratory and/or design work, analyze the obtained results and draw conclusions based on them | P7U_U | P7S_UU | |
| K2Ace_U14 | can take part in a discussion - initiate it, present different opinions and justify them | P7U_U | P7S_UK | |
| **SOCIAL COMPETENCES (K)** | | | | |

| | | | | |
|---|---|---|---|---|
| K2Ace_K01 | is ready to critically evaluate his knowledge and received content. | P7U_K | P7S_KK | |
| K2Ace_K02 | understands the need for entrepreneurial thinking and action and is aware of the need to act in the public interest. | P7U_K | P7S_KO | |
| K2Ace_K03 | understands the need to take initiatives, inspire and organize activities for the benefit of the socio-economic environment. | P7U_K | P7S_KO | |
| K2Ace_K04 | is ready to cooperate responsibly in a group, performing role taking into account the needs of the team (and/or social needs) | P7U_K | P7S_KR | |
| K2Ace_K05 | is ready to comply with the principles of professional ethics and respect the law, including copyright. | P7U_K | P7S_KR | |
| K2Ace_K06 | recognizes the importance and understands the non-technical aspects and consequences of scientific and engineering activities, including their impact on the environment, as well as the associated responsibilities. | P7U_K | P7S_KK<br>P7S_KO | |
| K2Ace_K07 | is aware of the social role of a technical university graduate and the need to maintain the ethos of the engineering profession. | P7U_K | P7S_KR | |
| K2Ace_K08 | is ready to recognize the importance of knowledge in solving problems in the field of study and related sciences; recognizes the need to seek expert opinion when difficulties arise in solving problems. | P7U_K | P7S_KK | |

**Zał. nr 3 do ZW 78/2023**

**Attachment no. 2. to the Program of Studies**

# DESCRIPTION OF THE PROGRAM OF STUDIES

| | |
|---|---|
| **Main field of study:** CHEMICAL ENGINEERING AND TECHNOLOGY | **Profile:** general academic |
| **Level of studies:** 2nd level studies (3-semestralne magisterskie) | **Form of studies:** full-time |

## 1. General description

| | |
|---|---|
| *1.1 Number of semesters:* ***3*** | *1.2 Total number of ECTS points necessary to complete studies at a given level:* ***90*** |
| *1.3 Total number of hours:* ***1095*** | *1.4 Prerequisites (particularly for second-level studies):* ***are specified in the regulation: "Conditions and mode of recruitment" at the Wrocław University of Science and Technology*** |
| *1.5 Upon completion of studies graduate obtains professional degree of:* ***magister inżynier*** | *1.6 Graduate profile, employability:* *A graduate of Chemical Engineering and Technology program should:* |

| | |
|---|---|
| | *- have specialized engineering and technical knowledge, including a deep understanding of the principles of chemical engineering and technology with elements of mathematics, physics and chemistry;*<br>*- have problem-solving skills, including the ability to analyze complex problems related to chemical processes and find innovative solutions;*<br>*- possess laboratory and experimental skills, including proficiency in conducting experiments, using laboratory equipment and interpreting experimental data;*<br>*-be safety conscious through good knowledge of chemical process safety procedures to minimize risks and hazards associated with working with chemicals and equipment.*<br>*-be environmentally conscious, including understanding the impact of chemical processes on the environment and processes that minimize environmental damage.*<br>*- have the ability to design and optimize chemical processes, taking into account factors such as efficiency, profitability and environmental impact;*<br>*-Have the communication skills, both written and oral, necessary to communicate complex technical information to colleagues, customers and the general public.*<br>*- have the ability to work in a team, necessary for chemical engineers who often work in multidisciplinary teams, also with the participation of specialists from various backgrounds.*<br>*- demonstrate ethical conduct in their work, adhering to the highest standards of professionalism and integrity in their field.*<br>*- have the ability to adapt and be open to continuous learning and improving their qualifications, especially important considering the* |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

| | |
|---|---|
| | *rapidly developing nature of this field, the development of new technologies and methods;*<br>*- understand the economic aspects of projects and have knowledge in project management.*<br>*- be aware of global problems in the chemical industry in order to be able to meet the requirements of the changing and dynamically developing industry.*<br>*A graduate of a master's degree in chemical engineering and technology has a high chance of being employed as a process engineer, project manager, quality control specialist or technician. Employment opportunities are found in various sectors, including the petrochemical industry, pharmaceutical industry, environmental engineering, plants producing materials (e.g. polymer and carbon for various applications), as well as in quality control laboratories, in the fuel and energy industries. The graduate can also find employment in research and development units.*<br>*A graduate completing studies in the field of Chemical Engineering and Technology should be prepared to plan and conduct scientific research, and thus undertake education at the Doctoral School.* |

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[4]University-wide subject /group of classes – enter O
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| | |
|---|---|
| *1.7 Possibility of continuing studies:*<br><br>***Eligibility to apply for admission to a doctoral school, non-degree postgraduate programmes*** | *1.8 Indicate connection with University's mission and its development strategy:*<br><br>*The mission and strategy of Wrocław University of Science and Technology were defined in the document entitled: "Strategy of Wrocław University of Science and Technology 2023-2030". The second-cycle study program in Chemical Engineering and Technology fits into the key areas of the strategy and the overarching strategic goals both in the area of education, scientific research and cooperation with the environment. It is also consistent with the mission of "creating and transmitting knowledge that responds to new challenges and opportunities emerging before society, economy and civilization.*<br>*The study program is consistent with the strategic goals by: (1) developing creative skills in the nature of scientific work through an increased number of classes related to the completion of a diploma thesis, (2) a large share (over 50%) of active classes, such as laboratories, exercises, seminars and projects , (3) ensuring a balance between the general and specialized knowledge, (4) providing students with knowledge and skills covering the latest achievements in the field of innovative process and chemical engineering and chemical technologies, (5) developing social competences, with particular emphasis on the development of skills teamwork, (6) developing the ability to work using the project method.* |

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[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
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**2. Detailed description**

**2.1 Total number of learning outcomes in the program of study: W (knowledge) =11, U (skills) = 14, K (competences) = 8**

**W + U + K = 33**

**2.2 For the main field of study assigned to more than one discipline - the number of learning outcomes assigned to the discipline:**

**D1 33 (major) (this number must be greater than half the total number of learning outcomes)**

**2.3 For the main field of study assigned to more than one discipline - percentage share of the number of ECTS points for each discipline:**

**D1 100% ECTS points**

**2.4a. For the general academic profile of the main field of study – the number of ECTS points assigned to the classes related to the University's academic activity in the discipline or disciplines to which the main field of study is assigned – DN (must be greater than 50% of the total number of ECTS points from 1.2**

| Specialization | Total number of ECTS points |
|---|---|
| ***Advanced chemical engineering (ACE)*** | 71 |
| ***Advanced chemical technology (ACT)*** | 77 |

**2.4b. For the practical profile of the main field of study - the number of ECTS points assigned to the classes shaping practical skills (must be greater than 50% of the total number of ECTS points from 1.2)**

**2.5 Concise analysis of compliance of the assumed learning outcomes with the needs of the labor market**

The chemical industry is characterized by a large diversity of processes and technologies, raw material base and manufactured products. This means that the expectations of the chemical industry towards graduates of chemical engineering and technology fields may vary depending on the specific industrial sector, type of company and current trends. Nevertheless, there are certain general competencies and skills that are often expected from graduates of degrees such as Chemical Engineering and Technology. They are indirectly presented in this study program under the Graduate profile item. The preparation of graduates listed there reflects, among others, the following learning outcomes:

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
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[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

- has in-depth knowledge of development trends and new achievements in the field of chemical engineering and technology. Is able to assess the usefulness and possibility of using new achievements in the field of chemical engineering,
- has advanced knowledge in the production of chemicals, polymers and specialized materials, understanding their role in the development of civilization.
- can use analytical methods and simulation programs to solve complex tasks in the field of chemical processes carried out on various scales,
- can design a system integrating various unit processes and justify its economics,
- demonstrates the ability to work in a team, taking on various roles (including leading),
- is able to independently plan and implement continuous education in the field of chemical engineering and related sciences; is able to pass on his knowledge to others.

**2.6 The total number of ECTS points that a student must obtain in classes requiring direct participation of academic teachers or other persons conducting classes and students** (enter the sum of ECTS points for subjects/ groups of classes marked with the BU[1] code)

| Specialization | Total number of ECTS points (BU) |
|---|---|
| ***Advanced chemical engineering (ACE)*** | 45,95 |
| ***Advanced chemical technology (ACT)*** | 46,35 |

**2.7. Total number of ECTS points, which student has to obtain from basic sciences classes**

| | ACE | ACT |
|---|---|---|
| Number of ECTS points for obligatory subjects | 4 | 4 |
| Number of ECTS points for optional subjects | 2 | 2 |
| Total number of ECTS points | **6** | **6** |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
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**2.8. Total number of ECTS points, which student has to obtain from practical classes, including project and laboratory classes** (enter total number of ECTS points for subjects/group of classes denoted with code P)

| | **ACE** | **ACT** |
|---|---|---|
| Number of ECTS points for obligatory subjects | 4 | 4 |
| Number of ECTS points for optional subjects | 61 | 65 |
| Total number of ECTS points | **65** | **69** |

**2.9. Minimum number of ECTS points, which student has to obtain doing education blocks offered as part of University-wide classes or other main field of study** (enter number of ECTS points for subjects/group of classes denoted with code O)

8 ECTS points

**2.10. Total number of ECTS points, which student may obtain doing optional blocks (min. 30% of total number of ECTS points)**

83ECTS points

**3. Description of the process leading to learning outcomes acquisition:**

Verification and assessment of learning outcomes with reference to subjects or groups of subjects throughout the entire education cycle is carried out in relation to the information contained in subject cards (syllabuses). As a rule, it is conducted through quizzes, tests and exams, during which the student is supposed to demonstrate an appropriate level of knowledge. Learning outcomes in the field of skills are verified during practical classes, as well as on the basis of reports, projects and final works.

The student acquires knowledge and skills by participating in theoretical and practical classes, which are largely based on the results of scientific research conducted by academic teachers - course supervisors and those conducting classes with students. The basis of education are laboratory, seminar and design subjects. Education in the field of study is conducted in accordance with the principle of increasing the complexity of theoretical and practical tasks faced by students. Modern teaching methods are implemented into teaching practice, thanks to which students' activity during classes increases. Theoretical subjects in the form of lectures and seminars are supplemented with design and laboratory classes, which include, among others: modeling and computer design, as well as conducting scientific research. The program is complemented by humanities subjects and foreign language courses. The course of study ends with a diploma examination checking the student's theoretical knowledge and the defense of a master's thesis.

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
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[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
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# 4. List of education blocks:

## 4.1. List of obligatory blocks:

### 4.1.1 List of general education blocks

#### 4.1.1.1 *Liberal-managerial subjects* block *(min. ..... ECTS points):*

| No. | Subject group of classes code | Name of subject group of classes (denote group of courses with symbol GK) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of Subject group of courses | Way[3] of crediting | Subject group of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University-wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| | | | | | | | | | | | | | | | | | | | |
| | | Total | | | | | | | | | | | | | | | | | |

#### 4.1.1.2 *Foreign languages* block *(min. ..... ECTS points):*

| No. | Subject group of classes code | Name of subject group of classes (denote group of courses with symbol GK) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of Subject group of courses | Way[3] of crediting | Subject group of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University-wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| | | | | | | | | | | | | | | | | | | | |
| | | Total | | | | | | | | | | | | | | | | | |

#### 4.1.1.3 *Sporting classes* block *(0 ECTS points):*

| No. | Subject group of classes code | Name of subject group of classes (denote group of courses with symbol GK) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of Subject group of courses | Way[3] of crediting | Subject group of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University-wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| | | | | | | | | | | | | | | | | | | | |
| | | Total | | | | | | | | | | | | | | | | | |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
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### 4.1.1.4 *Information technologies* block *(min. .... ECTS points):*

| No. | Subject group of classes code | Name of subject group of classes (denote group of courses with symbol GK) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of Subject group of courses | Way[3] of crediting | Subject group of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University -wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| | | | | | | | | | | | | | | | | | | | |
| | | Total | | | | | | | | | | | | | | | | | |

## Altogether for general education blocks

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Total number of ECTS points for DN classes[5] | Number of ECTS points for BU classes[1] |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| | | | | | | | | | |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## 4.1.2 List of basic sciences blocks

### 4.1.2.1 *Mathematics* block

| No. | Subject group of classescode | Name of subject group of classes (denote group of courses with symbol GK) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of Subject group of courses | Way[3] of crediting | Subject group of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University -wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| | | | | | | | | | | | | | | | | | | | |
| | | Total | | | | | | | | | | | | | | | | | |

### 4.1.2.2 *Physics* block

| No. | Subject group of classes code | Name of subject group of classes (denote group of courses with symbol GK) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of Subject group of courses | Way[3] of crediting | Subject group of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University -wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| | | | | | | | | | | | | | | | | | | | |
| | | Total | | | | | | | | | | | | | | | | | |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

### 4.1.2.3 *Chemistry* block

| No. | Subject group of classes code | Name of Subject group of classess (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of Subject group of courses | Way[3] of crediting | Subject group of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University-wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1. | W03CET-SM2010W | Green Chemistry and Sustainable Technology | 1 | | | | | K2Ace_W08; K2Ace_W09; K2Ace_W10; K2Ace_K07 | 15 | 25 | 1 | 1 | 0,6 | T/Z | **E** | | DN | | PD |
| 2 | W03CET-SM2010P | Green Chemistry and Sustainable Technology | | | | 2 | | K2Ace_U09, K2Ace_U10; K2Ace_U14; K2Ace_K04 | 30 | 75 | 3 | 3 | 1,5 | T/Z | Z | | DN | P | PD |
| | | **Total** | **1** | | | **2** | | | **45** | **100** | **4** | **4** | **2,1** | | **1** | | | **3** | |

## Altogether for basic sciences blocks:

| | Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Total number of ECTS points for DN classes[5] | Number of ECTS points for BU classes[1] |
|---|---|---|---|---|---|---|---|---|---|---|
| | w | ć | l | p | s | | | | | |
| ACE ACT | **1** | | | **2** | | **45** | **100** | **4** | **4** | **2,1** |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## 4.1.3 List of the main field of study blocks

### 4.1.3.1 *Obligatory main field of study* blocks

| No. | Subject group of classes code | Name of subject group of classes (denote group of courses with symbol GK) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of Subject group of courses | Way[3] of crediting | Subject group of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University -wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03CET-SM2004W | Trends in Chemical Engineering and Technology | 2 | | | | | K2Ace_W01; K2Ace_W06; K2Ace_W08; K2Ace_W10; K2Ace_W11; K2Ace_K01; K2Ace_K06 | 30 | 50 | 2 | 2 | 1,2 | T/Z | Z | | DN | | K |
| 2 | W03CET-SM2005C | Retrieval of Scientific and Technological Resources | | 1 | | | | K2Ace_W11; K2Ace_U08; K2Ace_K01; K2Ace_K08; | 15 | 25 | 1 | | 0,6 | T/Z | Z | | | P | K |
| | | **Total** | **2** | **1** | | | | | **45** | **75** | **3** | **2** | **1,8** | | | | | **1** | |

**Altogether (for main field of study blocks):**

| | Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Total number of ECTS points for DN classes[5] | Number of ECTS points for BU classes[1] |
|---|---|---|---|---|---|---|---|---|---|---|
| | w | ć | l | p | s | | | | | |
| ACE ACT | **2** | **1** | | | | **45** | **75** | **3** | **2** | **1,8** |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

# 4.2 List of optional blocks
## 4.2.1 List of general education blocks

### 4.2.1.1 Liberal-managerial subjects blocks *(min. 5 ECTS points):*

| No. | Subject group of classes code | Name of subject group of classes (denote group of courses with symbol GK) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of Subject group of courses | Way[3] of crediting | Subject group of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University-wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03SM-1002BH | Managerial course I | 1 | | | | | K2Ace_K02; K2Ace_K03; K2Ace_K07 | 15 | 60 | 2 | | 0,65 | T/Z | Z | O | | | KO |
| 2 | W03SM-1001BH | Managerial course II | 2 | | | | | K2Ace_K02; K2Ace_K03; K2Ace_K07 | 30 | 90 | 3 | | 1,3 | T/Z | Z | O | | | KO |
| | | **Total** | **3** | | | | | | **45** | **150** | **5** | | **1,95** | | | | | | |

### 4.2.1.2 ***Foreign languages*** **block** *(min. 3 ECTS points):*

| No. | Subject group of classes code | Name of subject group of classes (denote group of courses with symbol GK) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of Subject group of courses | Way[3] of crediting | Subject group of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University-wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | SJO-SM0004 | Foreign language I | | 1 | | | | K2Ace_U12; K2Ace_K01; K2Ace_K04 | 15 | 30 | 1 | | 0,6 | T/Z | Z | O | | P | KO |
| 2 | SJO-SM0003 | Foreign language II | | 3 | | | | K2Ace_U12; K2Ace_K01; K2Ace_K04 | 45 | 60 | 2 | | 1,8 | T/Z | Z | O | | P | KO |
| | | **Total** | | **4** | | | | | **60** | **90** | **3** | | **2,4** | | | | | **3** | |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## Altogether for general education blocks:

| | Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Total number of ECTS points for DN classes[5] | Number of ECTS points for BU classes[1] |
|---|---|---|---|---|---|---|---|---|---|---|
| | w | ć | l | p | s | | | | | |
| ACE ACT | **3** | **4** | | | | **105** | **240** | **8** | | **4,35** |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## 4.2.2 List of basic sciences blocks

### 4.2.2.1 *Mathematics* block

| No. | Subject group of classes code | Name of subject group of classes (denote group of courses with symbol GK) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of Subject group of courses | Way[3] of crediting | Subject group of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University -wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | **W03CET-SM20B1** | **Block: Mathematics for engineers*** | | **2** | | | | K2Ace_U01 K2Ace_K01 | **30** | **50** | **2** | | **1,3** | **T/Z** | **Z** | | | **P** | **PD** |
| | W03CET-SM2101c | 1. Planning experiments in Statistica | | 2 | | | | | 30 | 50 | 2 | | 1,3 | | | | | | |
| | W03CET-SM2102c | 2. Advanced analysis of experimental data | | 2 | | | | | 30 | 50 | 2 | | 1,3 | | | | | | |
| | | **Total** | | **2** | | | | | **30** | **50** | **2** | | **1,3** | | | | | **2** | |

### Altogether for basic sciences blocks:

| | Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Total number of ECTS points for DN classes[5] | Number of ECTS points for BU classes[1] |
|---|---|---|---|---|---|---|---|---|---|---|
| | lec | cl | lab | pr | sem | | | | | |
| ACE ACT | | **2** | | | | **30** | **50** | **2** | | **1,3** |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## 4.2.3 List of main-field of study blocks

### 4.2.3.1 ***Diploma profile*** **block** *(min. 29. ECTS points):*

| No. | Subject group of classes code | Name of subject group of classes (denote group of courses with symbol GK) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of Subject group of courses | Way[3] of crediting | Subject group of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University-wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03W03-SM2053S | Graduation proseminar | | | | | 1 | K2Ace_U08; K2Ace_U11; K2Ace_U14; K2Ace_K01; K2Ace_K07 | 15 | 25 | 1 | 1 | 0,7 | T/Z | Z | | DN | P | K |
| 2 | W03W03-SM2054D | Graduate laboratory I | | | 4 | | | K2Ace_U08; K2Ace_U09; K2Ace_K01; K2Ace_K05; K2Ace_K07 | 60 | 150 | 6 | 6 | 3 | T | Z | | DN | P | K |
| 3 | W03W03-SM2055D | Graduate laboratory II | | | 14 | | | K2Ace_U08; K2Ace_U09; K2Ace_U13; K2Ace_K01; K2Ace_K05; K2Ace_K07 | 210 | 500 | 20 | 20 | 9,5 | T | Z | | DN | P | K |
| 4 | W03W03-SM2056S | Graduation seminar | | | | | 1 | K2Ace_U11; K2Ace_U14; K2Ace_K01; K2Ace_K06; K2Ace_K07; K2Ace_K08 | 15 | 50 | 2 | 2 | 0,7 | T/Z | Z | | DN | P | K |
| | | **Total** | | | **18** | | **2** | | **300** | **725** | **29** | **29** | **13,9** | | | | | **29** | |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

### 4.2.3.2 *Optional courses* block

| No. | Subject group of classes code | Name of subject group of classes (denote group of courses with symbol GK) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of Subject group of courses | Way[3] of crediting | Subject group of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University-wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03CET-SM20BW | Elective course* | 2 | | | | | K2Ace_W06; K2Ace_K01; K2Ace_K07 | 30 | 50 | 2 | | 1,3 | T/Z | Z | | | | K |
| | | **Total** | **2** | | | | | | **30** | **50** | **2** | | **1,3** | | | | | | |

## Altogether for blocks:

| | Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Total number of ECTS points for DN classes[5] | Number of ECTS points for BU classes[1] |
|---|---|---|---|---|---|---|---|---|---|---|
| | lec | cl | lab | pr | sem | | | | | |
| ACE ACT | **2** | | **18** | | **2** | **330** | **775** | **31** | **29** | **15,2** |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## 4.2.4 List of specialization blocks

### 4.2.4.1 *Specialization subjects* blocks

***ACE Advanced Chemical Engineering*** *( min 42 ECTS)*

| No. | Subject group of classes code | Name of Subject group of courses (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of Subject group of courses | Way[3] of crediting | Subject group of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University-wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03CET-SM2001W | Chemical Process Equipment | 1 | | | | | K2Ace_W01; K2Ace_W03; K2Ace_K01; K2Ace_K06 | 15 | 50 | 2 | 2 | 0,6 | T/Z | **E** | | DN | | S |
| 2 | W03CET-SM2001P | Chemical Process Equipment | | | | 4 | | K2Ace_U04; K2Ace_U05; K2Ace_U06; K2Ace_K01; K2Ace_K02; | 60 | 100 | 4 | 4 | 2,4 | T/Z | Z | | DN | P | S |
| 3 | W03CET-SM2002W | Membrane Processes | 1 | | | | | K2Ace_W01; K2Ace_W08; K2Ace_K01; K2Ace_K06 | 15 | 50 | 2 | 2 | 0,6 | T/Z | Z | | DN | | S |
| 4 | W03CET-SM2002L | Membrane Processes | | | 3 | | | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_K01; K2Ace_K06; | 45 | 75 | 3 | 3 | 1,8 | T | Z | | DN | P | S |
| 5 | W03CET-SM2002S | Membrane Processes | | | | | 1 | K2Ace_U08; K2Ace_U11; K2Ace_U14; K2Ace_K01; K2Ace_K06; | 15 | 25 | 1 | 1 | 0,6 | T/Z | Z | | DN | P | S |
| 6 | W03CET-SM2003W | Heterogeneous Reactors | 2 | | | | | K2Ace_W01; K2Ace_W03; | 30 | 75 | 3 | 3 | 1,2 | T/Z | **E** | | DN | | S |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | K2Ace_W08;<br>K2Ace_U06;<br>K2Ace_K01;<br>K2Ace_K08; | | | | | | | | | | |
| 7 | W03CET-SM2003P | Heterogeneous Reactors | | | | 3 | | K2Ace_U01;<br>K2Ace_U04;<br>K2Ace_U05;<br>K2Ace_U06;<br>K2Ace_K01;<br>K2Ace_K08; | 45 | 75 | 3 | 3 | 1,8 | T/Z | Z | | DN | P | S |
| 8 | W03CET-SM2006W | Chemical Process Project with CFD calculations | 1 | | | | | K2Ace_W04;<br>K2Ace_W05;<br>K2Ace_K02;<br>K2Ace_K08 | 15 | 50 | 2 | 2 | 0,6 | T/Z | Z | | DN | | S |
| 9 | W03CET-SM2006P | Chemical Process Project with CFD calculations | | | | 4 | | K2Ace_U04;<br>K2Ace_U06;<br>K2Ace_U09;<br>K2Ace_K02;<br>K2Ace_K04 | 60 | 100 | 4 | 4 | 2,4 | T/Z | Z | | DN | P | S |
| 10 | W03CET-SM2007W | Biocatalysis in food, brewery and pharmaceutical industry | 1 | | | | | K2Ace_W01;<br>K2Ace_W06;<br>K2Ace_W08;<br>K2Ace_W10;<br>K2Ace_K01;<br>K2Ace_K03 | 15 | 50 | 2 | 2 | 0,6 | T/Z | Z | | DN | | S |
| 11 | W03CET-SM2007L | Biocatalysis in food, brewery and pharmaceutical industry | | | 3 | | | K2Ace_U02;<br>K2Ace_U03;<br>K2Ace_U04;<br>K2Ace_U07;<br>K2Ace_K01;<br>K2Ace_K06; | 45 | 75 | 3 | 3 | 1,8 | T | Z | | DN | P | S |
| 12 | W03CET-SM2007S | Biocatalysis in food, brewery and pharmaceutical industry | | | | | 1 | K2Ace_U08;<br>K2Ace_U11;<br>K2Ace_U14;<br>K2Ace_K01;<br>K2Ace_K06; | 15 | 25 | 1 | 1 | 0,6 | T/Z | Z | | DN | P | S |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | W03CET-SM2008W | Numerical applications in nanoengineering | 1 | | | | | K2Ace_W09; K2Ace_W08; K2Ace_K06; | 15 | 25 | 1 | 1 | 0,6 | T/Z | **E** | | DN | | S |
| 14 | W03CET-SM2008P | Numerical applications in nanoengineering | | | | 2 | | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_U07; K2Ace_K01; K2Ace_K06; | 30 | 50 | 2 | 2 | 1,2 | T/Z | Z | | DN | P | S |
| 15 | W03CET-SM2009W | Nanotechnology | 1 | | | | | K2Ace_W09; K2Ace_W06; K2Ace_W08; K2Ace_K06; | 15 | 25 | 1 | 1 | 0,6 | T/Z | Z | | DN | | S |
| 16 | W03CET-SM2009L | Nanotechnology | | | 2 | | | K2Ace_U02; K2Ace_U03; K2Ace_U07; K2Ace_K04; K2Ace_K06 | 30 | 50 | 2 | 2 | 1,2 | T | Z | | DN | P | S |
| 17 | W03CET-SM2011W | Chemical Process Optimization and Management | 1 | | | | | K2Ace_W02; K2Ace_W04; K2Ace_W07 K2Ace_W10; K2Ace_W11; K2Ace_K05; K2Ace_K07; | 15 | 50 | 2 | | 0,6 | T/Z | Z | | | | S |
| 18 | W03CET-SM2011P | Chemical Process Optimization and Management | | | | 4 | | K2Ace_U04; K2Ace_U05; K2Ace_U13; K2Ace_U07; K2Ace_K01; K2Ace_K02; K2Ace_K08 | 60 | 100 | 4 | | 2 | T/Z | Z | | | P | S |
| | | **Total** | **9** | | **8** | **17** | **2** | | **540** | **1050** | **42** | **36** | **21,2** | | **3** | | | **27** | |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## *ACT Advanced Chemical Technology ( min 42 ECTS)*

| No. | Subject group of classes code | Name of Subject group of courses (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of Subject group of courses | Way[3] of crediting | Subject group of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University-wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1. | W03CET-SM2012W | Advanced Chemical Technologies – Biorefinery technologies for chemicals and fuels | 1 | | | | | K2Ace_W01; K2Ace_W08; K2Ace_K01; K2Ace_K06 | 15 | 25 | 1 | 1 | 0,6 | T/Z | **E** | | DN | | S |
| 2. | W03CET-SM2012S | Advanced Chemical Technologies – Biorefinery technologies for chemicals and fuels | | | | | 1 | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_U07; K2Ace_U14; K2Ace_K01; K2Ace_K06; | 15 | 25 | 1 | 1 | 0,6 | T/Z | Z | | DN | P | S |
| 3. | W03CET-SM2012L | Advanced Chemical Technologies – Biorefinery technologies for chemicals and fuels | | | 3 | | | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_U07; K2Ace_K01; K2Ace_K06; | 45 | 100 | 4 | 4 | 1,8 | T | Z | | DN | P | S |
| 4. | W03CET-SM2013W | Surface Phenomena and Heterogenous Catalysis | 2 | | | | | K2Ace_W01; K2Ace_W08; K2Ace_K01; K2Ace_K06 | 30 | 50 | 2 | 2 | 1,2 | T/Z | **E** | | DN | | S |
| 5. | W03CET-SM2013S | Surface Phenomena and Heterogenous Catalysis | | | | | 1 | K2Ace_U08; K2Ace_U10; K2Ace_U11; K2Ace_U14; K2Ace_K01; K2Ace_K08; | 15 | 25 | 1 | 1 | 0,6 | T/Z | Z | | DN | P | S |
| 6. | W03CET-SM2013L | Surface Phenomena and Heterogenous Catalysis | | | 2 | | | K2Ace_U02; K2Ace_U03; K2Ace_U04; | 30 | 75 | 3 | 3 | 1,2 | T | Z | | DN | P | S |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | K2Ace_U07; K2Ace_K01; K2Ace_K06; | | | | | | | | | | | |
| 7. | W03CET-SM2014W | Industrial Plant Design Principles | 1 | | | | | K2Ace_W03; K2Ace_W04; K2Ace_W05 K2Ace_W07; K2Ace_W11; K2Ace_K02; K2Ace_K06 | 15 | 25 | 1 | 1 | 0,6 | T/Z | Z | | DN | | S |
| 8. | W03CET-SM2014P | Industrial Plant Design Principles | | | | 2 | | K2Ace_U01; K2Ace_U04; K2Ace_U05; K2Ace_U06; K2Ace_U13; K2Ace_K01; K2Ace_K08; | 30 | 50 | 2 | 2 | 1,5 | T/Z | Z | | DN | P | S |
| 9. | W03CET-SM2015W | Environmental protection in chemical industry | 1 | | | | | K2Ace_W09; K2Ace_W10; K2Ace_W11 K2Ace_K06 | 15 | 25 | 1 | 1 | | T/Z | Z | | DN | | S |
| 10. | W03CET-SM2015L | Environmental protection in chemical industry | | | 2 | | | K2Ace_U09; K2Ace_K06; K2Ace_K07 | 30 | 50 | 2 | 2 | 1,2 | T | Z | | DN | P | S |
| 11. | W03CET-SM2016W | Advanced Chemical Technologies – Modern macromolecular engineering materials | 2 | | | | | K2Ace_W09; K2Ace_W08; K2Ace_K06; | 30 | 50 | 2 | 2 | 1,2 | T/Z | **E** | | DN | | S |
| 12. | W03CET-SM2016L | Advanced Chemical Technologies – Modern macromolecular engineering materials | | | 3 | | | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_U07; K2Ace_K01; K2Ace_K06; | 45 | 100 | 4 | 4 | 1,8 | T | Z | | DN | P | S |
| 13. | W03CET-SM2017W | Chemical sensors and biosensors – fundamentals and applications | 1 | | | | | K2Ace_W05; K2Ace_W08; K2Ace_K05; K2Ace_K06; | 15 | 25 | 1 | 1 | 0,6 | T/Z | Z | | DN | | S |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14. | W03CET-SM2017L | Chemical sensors and biosensors – fundamentals and applications | | | 2 | | | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_U07; K2Ace_K01; K2Ace_K06; | 30 | 50 | 2 | 2 | 1,2 | T | Z | | DN | P | S |
| 15. | W03CET-SM2018W | Chemical reactors and bioreactors | 1 | | | | | K2Ace_W09; K2Ace_W08; K2Ace_K06; | 15 | 25 | 1 | 1 | 0,6 | T/Z | **E** | | DN | | S |
| 16. | W03CET-SM2018P | Chemical reactors and bioreactors | | | | 2 | | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_U07; K2Ace_U13; K2Ace_K01; K2Ace_K06; | 30 | 50 | 2 | 2 | 1,2 | T | Z | | DN | P | S |
| 17. | W03CET-SM2019P | Scientific team project | | | | 4 | | K2Ace_U07; K2Ace_U10; K2Ace_U11; K2Ace_K02; K2Ace_K04; K2Ace_K05; K2Ace_K08 | 60 | 150 | 6 | 6 | 3,0 | T | Z | | DN | P | S |
| 18. | W03CET-SM2020W | Advanced Chemical Technologies – Nanotechnologies and Energy | 2 | | | | | K2Ace_W09; K2Ace_W08; K2Ace_K06; | 30 | 50 | 2 | 2 | 1,2 | T/Z | **E** | | | | |
| 19. | W03CET-SM2020L | Advanced Chemical Technologies – Nanotechnologies and Energy | | | 3 | | | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_U07; K2Ace_K01; K2Ace_K06; | 45 | 100 | 4 | 4 | 1,5 | T | Z | | | P | S |
| | | **Total** | **11** | **0** | **15** | **8** | **2** | | **540** | **1050** | **42** | **42** | **21,6** | | **5** | | | **31** | |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## Altogether for specialization blocks:

| | Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Total number of ECTS points for DN classes[5] | Number of ECTS points for BU classes[1] |
|---|---|---|---|---|---|---|---|---|---|---|
| | lec | cl | lab | pr | sem | | | | | |
| ACE | **9** | **0** | **8** | **17** | **2** | **540** | **1050** | **42** | **36** | **21,2** |
| ACT | **11** | **0** | **15** | **8** | **2** | **540** | **1050** | **42** | **42** | **21,6** |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## 4.3 Training block - concerning principles of training crediting – attachment no.

***Not applicable***

### Opinion of the Advisory Faculty Council concerning the rules of crediting training block

| Name of training | | | |
|---|---|---|---|
| **Number of ECTS points** | **Number of ECTS points for BU[1] classes** | **Training crediting mode** | **Code** |
| | | | |

| Training duration | Training objective |
|---|---|
| | |

## 4.4 „Diploma dissertation" block

| Type of diploma dissertation | ~~Licencjat / inżynier~~ / magister / magister inżynier* | |
|---|---|---|
| **Number of diploma dissertation semesters** | **Number of ECTS points** | **Code** |
| **3** | **29** | W03W03-SM2053S<br>W03W03-SM2054D<br>W03W03-SM2055D<br>W03W03-SM2056S |

### Character of diploma dissertation

Thesis of the second cycle (master) should have traits of scientific, experimental or theoretical, with a primary or practical. Work should lead to new results of original research or technical and technological solutions, and its presentation in the form of written work should include the results and show the knowledge and skills of the author, including but not limited to:(1)The ability to formulate objectives and research questions; (2)Ability to use literature and other sources of knowledge ;(3)The ability to plan and carry out research and other activities to achieve its objectives and problems; (4)Ability to correctly interpret the results; (5)Ability to use precise and clear language and the proper matching of the images presented to illustrate the problem.

| **Number of BU[1] ECTS points** | **13,9** |
|---|---|

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## 5. Ways of verifying assumed learning outcomes

| Form of classes | Ways of verifying assumed learning outcomes |
|---|---|
| lecture | e.g. examination, progress/final test |
| class | e.g. progress/final test |
| laboratory | e.g. pretest, report from laboratory |
| project | e.g. project defense |
| seminar | e.g. participation in discussion, topic presentation, essay |
| diploma dissertation | prepared diploma dissertation |

## 6. Range of diploma examination

### Specialization ACE

1. Chemical reactors
2. Membrane Processes
3. Chemical nanoengineering
4. Processes in food, brewery and pharmaceutical industry
5. Design and optimization of chemical processes
6. Sustainable chemical technologies

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

**Specialization ACT**

1. Chemical reactors
2. Catalytic processes in the chemical industry
3. Technologies for producing nanomaterials
4. Biorefinery systems
5. Modern technologies for the production of polymers and composites
6. Sustainable chemical technologies

## 7. Requirements concerning deadlines for crediting subject/groups of subject for all courses in particular blocks

Each course should be passed in accordance with the study plan. If it is necessary to repeat a course, it should be completed in the next semester in which it is offered.

***T/Z** Remote form of classes requires Dean's approved, but cannot exceed 75 % of ECTS points.
T/Z option is accepted only for lectures, exercises and seminars

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

**8. Plan of studies (attachment no. 4)**

Approved by faculty student government legislative body:

| | |
|---|---|
| ..... | ..... |
| Date | name and surname, signature of student representative |

| | |
|---|---|
| ..... | ..... |
| Date | Dean’s signature |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

**Zał. nr 4 do ZW 78/2023**
**Attachment no. 3 to Program of Studies**

# PLAN OF STUDIES

**FACULTY**: **Chemistry**

**MAIN FIELD OF STUDY:** **CHEMICAL ENGINEERING AND TECHNOLOGY**

**EDUCATION LEVEL:** **second-level studies (3-semester)**

**FORM OF STUDIES**: **full-time studies**

**PROFILE:** **general academic**

**SPECIALIZATION**: **Advanced Chemical Engineering**

**LANGUAGE OF STUDY:** **English**

In effect since **2024/2025**

**Plan of studies structure (optionally)**

1) in ECTS point layout

*(space for scheme of plan)*

2) in hourly layout

*(space for scheme of plan)*

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

**2nd LEVEL STUDIES (MASTER LEVEL STUDIES) 3 sem** **2024/2025**

**Field of study: Chemical Engineering and Technology**

**Specialization: Advanced Chemical Engineering**

| Sem. | I | II | III |
|---|---|---|---|
| Godz. | 25h / 30ECTS / 2E | 26h / 30 ECTS / 2E | 22h / 30 ECTS |
| 26 | | Chemical Process Project with CFD calculations<br>1w+4p (2+4 ECTS) | |
| 25 | Chemical Process Equipment<br>1w+4p (2+4ECTS) **E** | | |
| 24 | | | |
| 23 | | | |
| 22 | | | Chemical Process Optimization and Management<br>1w+4p (2+4 ECTS) |
| 21 | | Biocatalysis in food, brewery and pharmaceutical industry<br>1w+3l +1s (2+3+1 ECTS) | |
| 20 | Membrane Processes<br>1w+3l+1s (2+3+1 ECTS) | | |
| 19 | | | |
| 18 | | | |
| 17 | | | Elective course<br>2w, 2 ECTS |
| 16 | | Numerical applications in nanoengineering<br>1w+2p (1+2 ECTS) **E** | |
| 15 | Heterogeneous reactors<br>2w+3p (3+3 ECTS) **E** | | Graduate laboratory II<br>14l (20 ECTS) |
| 14 | | | |
| 13 | | Nanotechnology<br>1w+2l (1+2 ECTS) | |
| 12 | | | |
| 11 | | | |
| 10 | Managerial course II<br>2w, 3 ECTS | Green Chemistry and Sustainable Technology<br>1w+2p, 4 ECTS **E** | |
| 9 | | | |
| 8 | Trends in Chemical Engineering and Technology,<br>2w 2 ECTS | | |
| 7 | | Foreign language II<br>3c (2 ECTS) | |
| 6 | Retrieval of Scientific and Technological Resources,<br>1c 1ECTS | | |
| 5 | Managerial course I<br>1w 2 ECTS | | |
| 4 | Block: Mathematics for engineers<br>2c (2 ECTS) | Graduate laboratory I<br>4l (6 ECTS) | |
| 3 | | | |
| 2 | Graduation proseminar<br>1s (1 ECTS) | | |
| 1 | Foreign language I<br>1c (1 ECTS) | | Graduation seminar<br>1s (2 ECTS) |
| Sem. | I | II | III |

# 1. Set of obligatory and optional subjects and groups of classes in semestral arrangement

## Semester 1

### Obligatory subjects / groups of classes Number of ECTS points 3

| No. | Subject / groups of classescode | Name of subject / groups of classes (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of subject / groups of classes | Way[3] of crediting | Subject / groups of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University -wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03CET-SM2004W | Trends in Chemical Engineering and Technology | 2 | | | | | K2Ace_W01; K2Ace_W06; K2Ace_W08; K2Ace_W10; K2Ace_W11; K2Ace_K01; K2Ace_K06 | 30 | 50 | 2 | 2 | 1,2 | T/Z | Z | | DN | | K |
| 2 | W03CET-SM2005C | Retrieval of Scientific and Technological Resources | | 1 | | | | K2Ace_W11; K2Ace_U08; K2Ace_K01; K2Ace_K08; | 15 | 25 | 1 | | 0,6 | T/Z | Z | | | P | K |
| | | **Total** | **2** | **1** | **0** | **0** | **0** | | **45** | **75** | **3** | **2** | **1,8** | | | | | **1** | |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

**Specialization subjects:** ***Advanced Chemical Engineering*** **Number of ECTS points 18**

| No. | Subject / groups of classescode | Name of subject / groups of classes (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of subject / groups of classes | Way[3] of crediting | Subject / groups of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University -wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03CET-SM2001W | Chemical Process Equipment | 1 | | | | | K2Ace_W01; K2Ace_W03; K2Ace_K01; K2Ace_K06 | 15 | 50 | 2 | 2 | 0,6 | T/Z | **E** | | DN | | S |
| 2 | W03CET-SM2001P | Chemical Process Equipment | | | | 4 | | K2Ace_U04; K2Ace_U05; K2Ace_U06; K2Ace_K01; K2Ace_K02; | 60 | 100 | 4 | 4 | 2,4 | T/Z | Z | | DN | P | S |
| 3 | W03CET-SM2002W | Membrane Processes | 1 | | | | | K2Ace_W01; K2Ace_W08; K2Ace_K01; K2Ace_K06 | 15 | 50 | 2 | 2 | 0,6 | T/Z | Z | | DN | | S |
| 4 | W03CET-SM2002L | Membrane Processes | | | 3 | | | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_K01; K2Ace_K06; | 45 | 75 | 3 | 3 | 1,8 | T | Z | | DN | P | S |
| 5 | W03CET-SM2002S | Membrane Processes | | | | | 1 | K2Ace_U08; K2Ace_U11; K2Ace_U14; K2Ace_K01; K2Ace_K06; | 15 | 25 | 1 | 1 | 0,6 | T/Z | Z | | DN | P | S |
| 6 | W03CET-SM2003W | Heterogeneous Reactors | 2 | | | | | K2Ace_W01; K2Ace_W03; K2Ace_W08; K2Ace_U06; K2Ace_K01; K2Ace_K08; | 30 | 75 | 3 | 3 | 1,2 | T/Z | **E** | | DN | | S |
| 7 | W03CET-SM2003P | Heterogeneous Reactors | | | | 3 | | K2Ace_U01; K2Ace_U04; K2Ace_U05; | 45 | 75 | 3 | 3 | 1,8 | T/Z | Z | | DN | P | S |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | K2Ace_U06; K2Ace_K01; K2Ace_K08; | | | | | | | | | | | |
| | | **Total** | **4** | **0** | **3** | **7** | **1** | | **225** | **450** | **18** | **18** | **9** | | **2** | | | **11** | |

## Optional subjects / groups of classes 9 ECTS points

| No. | Subject / groups of classescode | Name of subject / groups of classes (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of subject / groups of classes | Way[3] of crediting | Subject / groups of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University -wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03W03-SM2053S | Graduation proseminar | | | | | 1 | K2Ace_U08; K2Ace_U11; K2Ace_U14; K2Ace_K01; K2Ace_K07 | 15 | 25 | 1 | 1 | 0,7 | T/Z | Z | | DN | P | K |
| 2 | W03SM-1002BH | Managerial course I | 1 | | | | | K2Ace_K02; K2Ace_K03; K2Ace_K07 | 15 | 60 | 2 | | 0,65 | T/Z | Z | O | | | KO |
| 3 | W03SM-1001BH | Managerial course II | 2 | | | | | K2Ace_K02; K2Ace_K03; K2Ace_K07 | 30 | 90 | 3 | | 1,3 | T/Z | Z | O | | | KO |
| 4 | SJO-SM0004 | Foreign language I | | 1 | | | | K2Ace_U12; K2Ace_K01; K2Ace_K04 | 15 | 30 | 1 | | 0,6 | T/Z | Z | O | | P | KO |
| 5 | **W03CET-SM20B1** | **Block: Mathematics for engineers*** | | **2** | | | | K2Ace_U01 K2Ace_K01 | **30** | **50** | **2** | | **1,3** | **T/Z** | **Z** | | | **P** | **PD** |
| | W03CET-SM2101C | 1. Planning experiments in Statistica | | 2 | | | | | 30 | 50 | 2 | | 1,3 | | | | | | |
| | W03CET-SM2102C | 2. Advanced analysis of experimental data | | 2 | | | | | 30 | 50 | 2 | | 1,3 | | | | | | |
| | | **Total** | **3** | **3** | | | **1** | | **105** | **225** | **9** | **1** | **4,55** | | | | | **4** | |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## Altogether in semester

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Total number of ECTS points for DN classes[5] | Number of ECTS points for BU classes[1] |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| **9** | **4** | **3** | **7** | **2** | **375** | **750** | **30** | **21** | **15,35** |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## Semester 2

### Obligatory subjects / groups of classes  Number of ECTS points 4

| No. | Subject / groups of classescode | Name of subject / groups of classes (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of subject / groups of classes | Way[3] of crediting | Subject / groups of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University-wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03CET-SM2010W | Green Chemistry and Sustainable Technology | 1 | | | | | K2Ace_W08; K2Ace_W09; K2Ace_W10; K2Ace_K07 | 15 | 25 | 1 | 1 | 0,6 | T/Z | **E** | | DN | | PD |
| 2 | W03CET-SM2010P | Green Chemistry and Sustainable Technology | | | | 2 | | K2Ace_U09, K2Ace_U10; K2Ace_U14; K2Ace_K04 | 30 | 75 | 3 | 3 | 1,5 | T/Z | Z | | DN | P | PD |
| | | **Total** | **1** | | | **2** | | | **45** | **100** | **4** | **4** | **2,1** | | **1** | | | **3** | |

### Specialization subjects: *Advanced Chemical Engineering*  Number of ECTS points 18

| No. | Subject / groups of classescode | Name of subject / groups of classes (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of subject / groups of classes | Way[3] of crediting | Subject / groups of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University-wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03CET-SM2006W | Chemical Process Project with CFD calculations | 1 | | | | | K2Ace_W04; K2Ace_W05; K2Ace_K02; K2Ace_K08 | 15 | 50 | 2 | 2 | 0,6 | T/Z | Z | | DN | | S |
| 2 | W03CET-SM2006P | Chemical Process Project with CFD calculations | | | | 4 | | K2Ace_U04; K2Ace_U06; K2Ace_U09; K2Ace_K02; K2Ace_K04 | 60 | 100 | 4 | 4 | 2,4 | T/Z | Z | | DN | P | S |
| 3 | W03CET-SM2007W | Biocatalysis in food, brewery and pharmaceutical industry | 1 | | | | | K2Ace_W01; K2Ace_W06; K2Ace_W08; K2Ace_W10; | 15 | 50 | 2 | 2 | 0,6 | T/Z | Z | | DN | | S |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | K2Ace_K01; K2Ace_K03 | | | | | | | | | | |
| 4 | W03CET-SM2007L | Biocatalysis in food, brewery and pharmaceutical industry | | | 3 | | | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_U07; K2Ace_K01; K2Ace_K06; | 45 | 75 | 3 | 3 | 1,8 | T | Z | | DN | P | S |
| 5 | W03CET-SM2007S | Biocatalysis in food, brewery and pharmaceutical industry | | | | | 1 | K2Ace_U08; K2Ace_U11; K2Ace_U14; K2Ace_K01; K2Ace_K06; | 15 | 25 | 1 | 1 | 0,6 | T/Z | Z | | DN | P | S |
| 6 | W03CET-SM2008W | Numerical applications in nanoengineering | 1 | | | | | K2Ace_W09; K2Ace_W08; K2Ace_K06; | 15 | 25 | 1 | 1 | 0,6 | T/Z | **E** | | DN | | S |
| 7 | W03CET-SM2008P | Numerical applications in nanoengineering | | | | 2 | | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_U07; K2Ace_K01; K2Ace_K06; | 30 | 50 | 2 | 2 | 1,2 | T/Z | Z | | DN | P | S |
| 8 | W03CET-SM2009W | Nanotechnology | 1 | | | | | K2Ace_W09; K2Ace_W06; K2Ace_W08; K2Ace_K06; | 15 | 25 | 1 | 1 | 0,6 | T/Z | Z | | DN | | S |
| 9 | W03CET-SM2009L | Nanotechnology | | | 2 | | | K2Ace_U02; K2Ace_U03; K2Ace_U07; K2Ace_K04; K2Ace_K06 | 30 | 50 | 2 | 2 | 1,2 | T | Z | | DN | P | S |
| | | **Total** | **4** | | **5** | **6** | **1** | | **240** | **450** | **18** | **18** | **9,6** | | **1** | | | **12** | |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## Optional subjects / groups of classes 8 ECTS points

| No. | Subject / groups of classescode | Name of subject / groups of classes (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of subject / groups of classes | Way[3] of crediting | Subject / groups of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University -wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03W03-SM2054D | Graduate laboratory I | | | 4 | | | K2Ace_U08; K2Ace_U09; K2Ace_K01; K2Ace_K05; K2Ace_K07 | 60 | 150 | 6 | 6 | 3 | T | Z | | DN | P | K |
| 2 | SJO-SM0003 | Foreign language II | | 3 | | | | K2Ace_U12; K2Ace_K01; K2Ace_K04 | 45 | 60 | 2 | | 1,8 | T/Z | Z | O | | P | KO |
| | | **Total** | | **3** | **4** | | | | **105** | **210** | **8** | **6** | **4,8** | | | | | **8** | |

## Altogether in semester

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Total number of ECTS points for DN classes[5] | Number of ECTS points for BU classes[1] |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| **5** | **3** | **9** | **8** | **1** | **390** | **760** | **30** | **28** | **16,5** |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

# Semester 3

## Specialization subjects: *Advanced Chemical Engineering* Number of ECTS points 6

| No. | Subject / groups of classescode | Name of subject / groups of classes (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of subject / groups of classes | Way[3] of crediting | Subject / groups of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University -wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03CET-SM2011W | Chemical Process Optimization and Management | 1 | | | | | K2Ace_W02; K2Ace_W04; K2Ace_W07 K2Ace_W10; K2Ace_W11; K2Ace_K05; K2Ace_K07; | 15 | 50 | 2 | | 0,6 | T/Z | Z | | | | S |
| 2 | W03CET-SM2011P | Chemical Process Optimization and Management | | | | 4 | | K2Ace_U04; K2Ace_U05; K2Ace_U13; K2Ace_U07; K2Ace_K01; K2Ace_K02; K2Ace_K08 | 60 | 100 | 4 | | 2 | T/Z | Z | | | P | S |
| | | **Total** | **1** | | | **4** | | | **75** | **150** | **6** | | **2,6** | | **1** | | | **4** | |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## Optional subjects / groups of classes 24 ECTS points

| No. | Subject / groups of classescode | Name of subject / groups of classes (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of subject / groups of classes | Way[3] of crediting | Subject / groups of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University -wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03W03-SM2055D | Graduate laboratory II | | | 14 | | | K2Ace_U08; K2Ace_U09; K2Ace_U13; K2Ace_K01; K2Ace_K05; K2Ace_K07 | 210 | 500 | 20 | 20 | 9,5 | T | Z | | DN | P | K |
| 2 | W03W03-SM2056S | Graduation seminar | | | | | 1 | K2Ace_U11; K2Ace_U14; K2Ace_K01; K2Ace_K06; K2Ace_K07; K2Ace_K08 | 15 | 50 | 2 | 2 | 0,7 | T/Z | Z | | DN | P | K |
| 3 | W03CET-SM20BW | Elective course* | 2 | | | | | K2Ace_W06; K2Ace_K01; K2Ace_K07 | 30 | 50 | 2 | | 1,3 | T/Z | Z | | | | K |
| | | **Total** | **2** | | **14** | | **1** | | **255** | **600** | **24** | **22** | **11,5** | | | | | **22** | |

## Altogether in semester

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Total number of ECTS points for DN classes[5] | Number of ECTS points for BU classes[1] |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| **3** | | **14** | **4** | **1** | **330** | **750** | **30** | **22** | **14,1** |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## 2. Set of examinations in semestral arrangement

| Subject / groups of classescode | Names of subjects / groups of classesending with examination | Semester |
|---|---|---|
| W03CET-SM2001W | Chemical process equipment | 1 |
| W03CET-SM2003W | Heterogeneous reactors | |
| W03CET-SM2008W | Numerical applications in nanoengineering | 2 |
| W03CET-SM2010W | Green chemistry and sustainable technology | |
| | ---------- | 3 |

## 3. Numbers of allowable deficit of ECTS points after particular semesters

| Semester | Allowable deficit of ECTS points after semester |
|---|---|
| 1 | 15 |
| 2 | 15 |
| 3 | 0 |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Opinion of student government legislative body

| | |
|---|---|
| ..... | ..... |
| Date | Name and surname, signature of student representative |

| | |
|---|---|
| ..... | ..... |
| Date | Dean’s signature |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

**Zał. nr 4 do ZW 78/2023**
**Attachment no. 3 to Program of Studies**

# PLAN OF STUDIES

**FACULTY**: **Chemistry**

**MAIN FIELD OF STUDY:** **CHEMICAL ENGINEERING AND TECHNOLOGY**

**EDUCATION LEVEL:** **second-level studies (3-semester)**

**FORM OF STUDIES**: **full-time studies**

**PROFILE:** **general academic**

**SPECIALIZATION**: **Advanced Chemical Technology**

**LANGUAGE OF STUDY:** **English**

In effect since **2024/2025**

**Plan of studies structure (optionally)**

1) in ECTS point layout

*(space for scheme of plan)*

2) in hourly layout

*(space for scheme of plan)*

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

**2nd LEVEL STUDIES (MASTER LEVEL STUDIES) 3 sem** **2024/2025**

**Field of study: Chemical Engineering and Technology**

**Specialization: Advanced Chemical Technology**

<table>
<tr><td>Sem.</td><td>I</td><td>II</td><td>III</td></tr>
<tr><td>Godz.</td><td>26h / 30ECTS / 2E</td><td>25h / 30 ECTS / 3E</td><td>22h / 30 ECTS / 1E</td></tr>
<tr><td>26</td><td rowspan="4">Advanced Chemical Technologies – Biorefinery technologies for chemicals and fuels<br>1w+1s+3l (6 ECTS) E</td><td></td><td rowspan="3"></td></tr>
<tr><td>25</td><td rowspan="3">Advanced Chemical Technologies – Modern macromolecular engineering materials<br>2w + 3l (6 ECTS) E</td></tr>
<tr><td>24</td></tr>
<tr><td>23</td></tr>
<tr><td>22</td><td rowspan="4">Advanced Chemical Technologies – Nanotechnologies and Energy<br>5h (6 ECTS) – 2w + 3l E</td></tr>
<tr><td>21</td><td rowspan="4">Surface Phenomena and Heterogenous Catalysis<br>2w+1s+2l (6ECTS) E</td></tr>
<tr><td>20</td><td rowspan="3">Chemical sensors and biosensors – fundamentals and applications<br>1w + 2l (3 ECTS)</td></tr>
<tr><td>19</td></tr>
<tr><td>18</td></tr>
<tr><td>17</td><td rowspan="3">Chemical reactors and bioreactors<br>1w+ 2p (3 ECTS) E</td><td>Elective course<br>2w, 2 ECTS</td></tr>
<tr><td>16</td><td rowspan="3">Industrial plants design principles<br>1w+2p 3ECTS</td><td rowspan="9">Graduate laboratory II<br>14l (20 ECTS)</td></tr>
<tr><td>15</td></tr>
<tr><td>14</td><td rowspan="3">Scientific team project (elective)<br>Module 1A: computational project<br>Module 1B: laboratory project<br>4p (6ECTS)</td></tr>
<tr><td>13</td><td rowspan="3">Environmental protection in chemical industry<br>1w+2l (1+2 ECTS)</td></tr>
<tr><td>12</td></tr>
<tr><td>11</td></tr>
<tr><td>10</td><td rowspan="2">Managerial course II<br>2w, 3 ECTS</td><td rowspan="2">Green Chemistry and Sustainable Technology,<br>1w+2p, 4 ECTS E</td></tr>
<tr><td>9</td></tr>
<tr><td>8</td><td rowspan="2">Trends in Chemical Engineering and Technology,<br>2w 2 ECTS</td><td rowspan="3">Foreign language II<br>3c (2 ECTS)</td></tr>
<tr><td>7</td></tr>
<tr><td>6</td><td>Retrieval of Scientific and Technological Resources,<br>1c 1ECTS</td></tr>
<tr><td>5</td><td>Managerial course I<br>1w 2 ECTS</td><td rowspan="5">Graduate laboratory I<br>4l (6 ECTS)</td></tr>
<tr><td>4</td><td rowspan="2">Block: Mathematics for engineers<br>2c (2 ECTS)</td></tr>
<tr><td>3</td></tr>
<tr><td>2</td><td>Graduation proseminar<br>1s (1 ECTS)</td></tr>
<tr><td>1</td><td>Foreign language I,<br>1c (1 ECTS)</td><td>Graduation seminar<br>1s (2 ECTS)</td></tr>
<tr><td>Sem.</td><td>I</td><td>II</td><td>III</td></tr>
</table>

# 1. Set of obligatory and optional subjects and groups of classes in semestral arrangement

## Semester 1

### Obligatory subjects / groups of classes  Number of ECTS points 3

| No. | Subject / groups of classes code | Name of subject / groups of classes (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of subject / groups of classes | Way[3] of crediting | Subject / groups of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University -wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03CET-SM2004W | Trends in Chemical Engineering and Technology | 2 | | | | | K2Ace_W01; K2Ace_W06; K2Ace_W08; K2Ace_W10; K2Ace_W11; K2Ace_K01; K2Ace_K06 | 30 | 50 | 2 | 2 | 1,2 | T/Z | Z | | DN | | K |
| 2 | W03CET-SM2005C | Retrieval of Scientific and Technological Resources | | 1 | | | | K2Ace_W11; K2Ace_U08; K2Ace_K01; K2Ace_K08; | 15 | 25 | 1 | | 0,6 | T/Z | Z | | | P | K |
| | | **Total** | **2** | **1** | **0** | **0** | **0** | | **45** | **75** | **3** | **2** | **1,8** | | | | | **1** | |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

**Specialization subjects:** ***Advanced Chemical Technology*** **Number of ECTS points 18**

| No. | Subject / groups of classes code | Name of subject / groups of classes (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of subject / groups of classes | Way[3] of crediting | Subject / groups of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University -wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03CET-SM2012W | Advanced Chemical Technologies – Biorefinery technologies for chemicals and fuels | 1 | | | | | K2Ace_W01; K2Ace_W08; K2Ace_K01; K2Ace_K06 | 15 | 25 | 1 | 1 | 0,6 | T/Z | **E** | | DN | | S |
| 2 | W03CET-SM2012S | Advanced Chemical Technologies – Biorefinery technologies for chemicals and fuels | | | | | 1 | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_U07; K2Ace_U14; K2Ace_K01; K2Ace_K06; | 15 | 25 | 1 | 1 | 0,6 | T/Z | Z | | DN | P | S |
| 3 | W03CET-SM2012L | Advanced Chemical Technologies – Biorefinery technologies for chemicals and fuels | | | 3 | | | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_U07; K2Ace_K01; K2Ace_K06; | 45 | 100 | 4 | 4 | 1,8 | T | Z | | DN | P | S |
| 4 | W03CET-SM2013W | Surface Phenomena and Heterogenous Catalysis | 2 | | | | | K2Ace_W01; K2Ace_W08; K2Ace_K01; K2Ace_K06 | 30 | 50 | 2 | 2 | 1,2 | T/Z | **E** | | DN | | S |
| 5 | W03CET-SM2013S | Surface Phenomena and Heterogenous Catalysis | | | | | 1 | K2Ace_U08; K2Ace_U10; K2Ace_U11; K2Ace_U14; K2Ace_K01; K2Ace_K08; | 15 | 25 | 1 | 1 | 0,6 | T/Z | Z | | DN | P | S |
| 6 | W03CET-SM2013L | Surface Phenomena and Heterogenous Catalysis | | | 2 | | | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_U07; | 30 | 75 | 3 | 3 | 1,2 | T | Z | | DN | P | S |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | K2Ace_K01; K2Ace_K06; | | | | | | | | | | | |
| 7 | W03CET-SM2014W | Industrial Plant Design Principles | 1 | | | | | K2Ace_W03; K2Ace_W04; K2Ace_W05 K2Ace_W07; K2Ace_W11; K2Ace_K02; K2Ace_K06 | 15 | 25 | 1 | 1 | 0,6 | T/Z | Z | | DN | | S |
| 8 | W03CET-SM2014P | Industrial Plant Design Principles | | | | 2 | | K2Ace_U01; K2Ace_U04; K2Ace_U05; K2Ace_U06; K2Ace_U13; K2Ace_K01; K2Ace_K08; | 30 | 50 | 2 | 2 | 1,5 | T/Z | Z | | DN | P | S |
| 9 | W03CET-SM2015W | Environmental protection in chemical industry | 1 | | | | | K2Ace_W09; K2Ace_W10; K2Ace_W11 K2Ace_K06 | 15 | 25 | 1 | 1 | | T/Z | Z | | DN | | S |
| 10 | W03CET-SM2015L | Environmental protection in chemical industry | | | 2 | | | K2Ace_U09; K2Ace_K06; K2Ace_K07 | 30 | 50 | 2 | 2 | 1,2 | T | Z | | DN | P | S |
| | | **Total** | **5** | **0** | **7** | **2** | **2** | **0** | **240** | **450** | **18** | **18** | **9,3** | | **2** | | | **13** | |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## Optional subjects / groups of classes 9 ECTS points

| No. | Subject / groups of classes code | Name of subject / groups of classes (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of subject / groups of classes | Way[3] of crediting | Subject / groups of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University -wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03W03-SM2053S | Graduation proseminar | | | | | 1 | K2Ace_U08; K2Ace_U11; K2Ace_U14; K2Ace_K01; K2Ace_K07 | 15 | 25 | 1 | 1 | 0,7 | T/Z | Z | | DN | P | K |
| 2 | W03SM-1002BH | Managerial course I | 1 | | | | | K2Ace_K02; K2Ace_K03; K2Ace_K07 | 15 | 60 | 2 | | 0,65 | T/Z | Z | O | | | KO |
| 3 | W03SM-1001BH | Managerial course II | 2 | | | | | K2Ace_K02; K2Ace_K03; K2Ace_K07 | 30 | 90 | 3 | | 1,3 | T/Z | Z | O | | | KO |
| 4 | SJO-SM0004 | Foreign language I | | 1 | | | | K2Ace_U12; K2Ace_K01; K2Ace_K04 | 15 | 30 | 1 | | 0,6 | T/Z | Z | O | | P | KO |
| 5 | **W03CET-SM20B1** | **Block: Mathematics for engineers** | | **2** | | | | K2Ace_U01 K2Ace_K01 | **30** | **50** | **2** | | **1,3** | **T/Z** | **Z** | | | **P** | **PD** |
| | W03CET-SM2101C | 1. Planning experiments in Statistica | | 2 | | | | | 30 | 50 | 2 | | 1,3 | | | | | | |
| | W03CET-SM2102C | 2. Advanced analysis of experimental data | | 2 | | | | | 30 | 50 | 2 | | 1,3 | | | | | | |
| | | **Total** | **3** | **3** | | | **1** | | **105** | **225** | **9** | **1** | **4,55** | | | | | **4** | |

## Altogether in semester

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Total number of ECTS points for DN classes[5] | Number of ECTS points for BU classes[1] |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| **10** | **4** | **7** | **2** | **3** | **390** | **750** | **30** | **21** | **15,65** |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## Semester 2

### Obligatory subjects / groups of classes  Number of ECTS points 4

| No. | Subject / groups of classes code | Name of subject / groups of classes (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of subject / groups of classes | Way[3] of crediting | Subject / groups of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University-wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03CET-SM2010W | Green Chemistry and Sustainable Technology | 1 | | | | | K2Ace_W08; K2Ace_W09; K2Ace_W10; K2Ace_K07 | 15 | 25 | 1 | 1 | 0,6 | T/Z | **E** | | DN | | PD |
| 2 | W03CET-SM2010P | Green Chemistry and Sustainable Technology | | | | 2 | | K2Ace_U09, K2Ace_U10; K2Ace_U14; K2Ace_K04 | 30 | 75 | 3 | 3 | 1,5 | T/Z | Z | | DN | P | PD |
| | | **Total** | **1** | | | **2** | | | **45** | **100** | **4** | **4** | **2,1** | | **1** | | | **3** | |

### Specialization subjects: *Advanced Chemical Technology*  Number of ECTS points 18

| No. | Subject / groups of classes code | Name of subject / groups of classes (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of subject / groups of classes | Way[3] of crediting | Subject / groups of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University-wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03CET-SM2016W | Advanced Chemical Technologies – Modern macromolecular engineering materials | 2 | | | | | K2Ace_W09; K2Ace_W08; K2Ace_K06; | 30 | 50 | 2 | 2 | 1,2 | T/Z | **E** | | DN | | S |
| 2 | W03CET-SM2016L | Advanced Chemical Technologies – Modern macromolecular engineering materials | | | 3 | | | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_U07; K2Ace_K01; K2Ace_K06; | 45 | 100 | 4 | 4 | 1,8 | T | Z | | DN | P | S |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | W03CET-SM2017W | Chemical sensors and biosensors – fundamentals and applications | 1 | | | | | K2Ace_W05; K2Ace_W08; K2Ace_K05; K2Ace_K06; | 15 | 25 | 1 | 1 | 0,6 | T/Z | Z | | DN | | S |
| 4 | W03CET-SM2017L | Chemical sensors and biosensors – fundamentals and applications | | | 2 | | | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_U07; K2Ace_K01; K2Ace_K06; | 30 | 50 | 2 | 2 | 1,2 | T | Z | | DN | P | S |
| 5 | W03CET-SM2018W | Chemical reactors and bioreactors | 1 | | | | | K2Ace_W09; K2Ace_W08; K2Ace_K06; | 15 | 25 | 1 | 1 | 0,6 | T/Z | **E** | | DN | | S |
| 6 | W03CET-SM2018P | Chemical reactors and bioreactors | | | | 2 | | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_U07; K2Ace_U13; K2Ace_K01; K2Ace_K06; | 30 | 50 | 2 | 2 | 1,2 | T | Z | | DN | P | S |
| 7 | W03CET-SM2019P | Scientific team project | | | | 4 | | K2Ace_U07; K2Ace_U10; K2Ace_U11; K2Ace_K02; K2Ace_K04; K2Ace_K05; K2Ace_K08 | 60 | 150 | 6 | 6 | 3,0 | T | Z | | DN | P | S |
| | | **Total** | **4** | **0** | **5** | **6** | **0** | | **225** | **450** | **18** | **18** | **9,6** | | **2** | | | **14** | |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## Optional subjects / groups of classes 8 ECTS points

| No. | Subject / groups of classes code | Name of subject / groups of classes (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of subject / groups of classes | Way[3] of crediting | Subject / groups of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University -wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03W03-SM2054D | Graduate laboratory I | | | 4 | | | K2Ace_U08; K2Ace_U09; K2Ace_K01; K2Ace_K05; K2Ace_K07 | 60 | 150 | 6 | 6 | 3 | T | Z | | DN | P | K |
| 2 | SJO-SM0003 | Foreign language II | | 3 | | | | K2Ace_U12; K2Ace_K01; K2Ace_K04 | 45 | 60 | 2 | | 1,8 | T/Z | Z | O | | P | KO |
| | | **Total** | | **3** | **4** | | | | **105** | **210** | **8** | **6** | **4,8** | | | | | **8** | |

## Altogether in semester

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Total number of ECTS points for DN classes[5] | Number of ECTS points for BU classes[1] |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| **5** | **3** | **9** | **8** | **0** | **375** | **760** | **30** | **28** | **16,5** |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

# Semester 3

## Specialization subjects: *Advanced Chemical Technology* Number of ECTS points 6

| No. | Subject / groups of classes code | Name of subject / groups of classes (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of subject / groups of classes | Way[3] of crediting | Subject / groups of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University -wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03CET-SM2020W | Advanced Chemical Technologies – Nanotechnologies and Energy | 2 | | | | | K2Ace_W09; K2Ace_W08; K2Ace_K06; | 30 | 50 | 2 | 2 | 1,2 | T/Z | **E** | | | | S |
| 2 | W03CET-SM2020L | Advanced Chemical Technologies – Nanotechnologies and Energy | | | 3 | | | K2Ace_U02; K2Ace_U03; K2Ace_U04; K2Ace_U07; K2Ace_K01; K2Ace_K06; | 45 | 100 | 4 | 4 | 1,5 | T | Z | | | P | S |
| | | **Total** | **2** | | **3** | | | | **75** | **150** | **6** | **6** | **2,7** | | **1** | | | **4** | |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## Optional subjects / groups of classes 24 ECTS points

| No. | Subject / groups of classes code | Name of subject / groups of classes (denote group of courses with symbol **GK**) | Weekly number of hours | | | | | Learning effect symbol | Number of hours | | Number of ECTS points | | | Form[2] of subject / groups of classes | Way[3] of crediting | Subject / groups of classes | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | lec | cl | lab | pr | sem | | ZZU | CNPS | Total | DN[5] classes | BU[1] classes | | | University -wide[4] | Concerning scientific activities[5] | Practical[6] | Type[7] |
| 1 | W03W03-SM2055D | Graduate laboratory II | | | 14 | | | K2Ace_U08; K2Ace_U09; K2Ace_U13; K2Ace_K01; K2Ace_K05; K2Ace_K07 | 210 | 500 | 20 | 20 | 9,5 | T | Z | | DN | P | K |
| 2 | W03W03-SM2056S | Graduation seminar | | | | | 1 | K2Ace_U11; K2Ace_U14 K2Ace_K01; K2Ace_K06; K2Ace_K07; K2Ace_K08 | 15 | 50 | 2 | 2 | 0,7 | T/Z | Z | | DN | P | K |
| 3 | W03CET-SM20BW | Elective course* | 2 | | | | | K2Ace_W06; K2Ace_K01; K2Ace_K07 | 30 | 50 | 2 | | 1,3 | T/Z | Z | | | | K |
| | | **Total** | **2** | | **14** | | **1** | | **255** | **600** | **24** | **22** | **11,5** | | | | | **22** | |

## Altogether in semester

| Total number of hours | | | | | Total number of ZZU hours | Total number of CNPS hours | Total number of ECTS points | Total number of ECTS points for DN classes[5] | Number of ECTS points for BU classes[1] |
|---|---|---|---|---|---|---|---|---|---|
| lec | cl | lab | pr | sem | | | | | |
| **4** | | **17** | | **1** | **330** | **750** | **30** | **28** | **14,2** |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

## 2. Set of examinations in semestral arrangement

| Subject / groups of classes code | Names of subjects / groups of classes ending with examination | Semester |
|---|---|---|
| W03CET-SM2012W | Advanced Chemical Technologies – Biorefinery technologies for chemicals and fuels | 1 |
| W03CET-SM2013W | Surface Phenomena and Heterogenous Catalysis | |
| W03CET-SM2016W | Advanced Chemical Technologies – Modern macromolecular engineering materials | 2 |
| W03CET-SM2018W | Chemical reactors and bioreactors | |
| W03CET-SM2010W | Green chemistry and sustainable technology | |
| W03CET-SM2020W | Advanced Chemical Technologies – Nanotechnologies and Energy | 3 |

## 3. Numbers of allowable deficit of ECTS points after particular semesters

| Semester | Allowable deficit of ECTS points after semester |
|---|---|
| 1 | 15 |
| 2 | 15 |
| 3 | 0 |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Opinion of student government legislative body

| | |
|---|---|
| ..... | ..... |
| Date | Name and surname, signature of student representative |

| | |
|---|---|
| ..... | ..... |
| Date | Dean’s signature |

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

# KARTY PRZEDMIOTÓW

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY OF CHEMISTRY

**SUBJECT CARD**

**Name of subject in Polish** **Zaawansowane technologie chemiczne – technologie biorafineryjne dla chemikaliów i paliw**

**Name of subject in English :** **Advanced Chemial Technologies – Biorafinery technologies for chemicals and fuels**

**Main field of study (if applicable):** Chemical Engineering and Technology

**Specialization (if applicable):** Advanced Chemical Technology

**Profile:** academic

**Level and form of studies:** 2nd level, full-time

**Kind of subject:** obligatory

**Subject code** W03CET-SM2012W, W03CET-SM2012L, W03CET-SM2012S

**Group of courses:** NO

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 15 | | 45 | | 15 |
| Number of hours of total student workload (CNPS) | 25 | | 100 | | 25 |
| Form of crediting (Examination / crediting with grade) | exam | | crediting with grade | | crediting with grade |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | 1 | | 4 | | 1 |
| including number of ECTS points for practical classes (P) | | | 4 | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0,6 | | 1,8 | | 0,6 |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

n/a

## SUBJECT OBJECTIVES

C1 to familiarize students with biorefinery systems for the production of chemicals
C2 presentation of issues related to fuel production in biorefineries
C3 developing the student's skills in planning and conducting technological and biotechnological processes

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:

PEU_W01 the student has advanced knowledge of modern biorefinery technologies focused on the production of chemicals and fuels

PEU_W02 the student knows the principles of sustainable development in relation to biorefineries

PEU_W03 the student knows the latest trends in the development of biorefinery systems

relating to skills:

PEU_U01student is able to plan and carry out biomass conversion processes towards biofuels

PEU_U02 the student is able to plan and carry out biomass conversion processes towards chemicals

PEU_U03 the student critically processes the information obtained in the field of processes and technologies used in biorefineries, is able to discuss

PEU_U04 the student demonstrates the ability to work in a team

relating to social competences:

PEU_K01 the student is ready to critically evaluate his knowledge

PEU_K02 is aware of the importance of technical and non-technical aspects related to the operation of a biorefinery, also in the context of environmental protection and sustainable development goals

**PROGRAMME CONTENT**

| | **Lecture** | **Number of hours** |
|---|---|---|
| Wy1 | Principles of a sustainable biorefinery. Biomass resources for use in biorefineries. | 2 |
| Wy2-Wy4 | Biorefinery technologies for chemical production Biorefinery approach to the production of industrially important C4, C5 and C6 chemicals | 5 |
| Wy4-Wy6 | Biorefinery technologies in the production of alternative fuels and energy. Biorefinery production of bioethanol and biomethanol. Oleorefineries. Biogas plants – production and applications of biogas. | 5 |
| Wy7 | Biochemical and thermochemical microalgae | 2 |
| Wy8 | Enzymes in biorefinery systems | 1 |
| | Total hours | **15** |

| | **Laboratory** | **Number of hours** |
|---|---|---|
| Lab 1 | Occupational health and safety rules, discussion of the conditions for passing the exam | 1 |
| Lab 2 | Production and characteristics of liquid biofuels | 12 |
| Lab 3 | Microalgae – a modern raw material in biorefinery systems | 8 |
| Lab 4 | Conversion of sugars and polysaccharides into chemicals | 12 |
| Lab 5 | Production and characterization of fine chemicals | 12 |
| | Total hours | 45 |

| **Seminar** | **Number of hours** |
|---|---|

| | | |
|---|---|---|
| Se1 | Biorefineries in the concept of sustainable development | 2 |
| Se2 | Levulinic acid – a modern chemical platform | 2 |
| Se3 | Biofuels – bioethanol, biomethanol | 2 |
| Se4 | Biofuels – biodiesel | 2 |
| Se5 | Biodegradable polymers as environmentally friendly materials | 2 |
| Se6 | Microalgae – a modern raw material in biorefinery systems | 2 |
| Se7 | Bioactive phytochemicals. Preparation, characteristics and applications. | 2 |
| Se8 | Summary discussions | 1 |
| | Total hours | 15 |

**TEACHING TOOLS USED**

N1. Multimedia presentation
N2. Discussion
N3. Case study
N4. Laboratory instructions

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| F1=P (lecture) | PEU_W01-PEU_W03, PEU_K01 | Exam result (50% of points required to pass) + 10% for activity (possibility of increasing the grade by 0.5) |
| F2=P (laboratory) | PEU_U01, PEU_U02, PEU_U04, PEU_K01 | Grades from reports, evaluation of laboratory work, activity |
| F3=P (seminar) | PEU_U03, PEU_U04, PEU_K01, PEU_K02 | Quality of presentation, assessment of individual and group work |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

[1] Biorefineries: Production of Fuels and Platform Chemicals, Wiley&Sons 2024, ISBN-13: 9781119724728
[2] Biorefinery: A Sustainable Approach for the Production of Biomaterials, Biochemicals and Biofuels, Springer 2023
[3] Biorefinery Integrated Sustainable Processes for Biomass Conversion to Biomaterials, Biofuels, and Fertilizers, Springer 2019

**SECONDARY LITERATURE:**

[1] Specialized literature provided by the teacher at the beginning of the class
[2] Laboratory instructions

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

Team of lecturers

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY OF CHEMISTRY

**SUBJECT CARD**

**Name of subject in Polish** Nowoczesne wielkocząsteczkowe materiały inżynierskie
**Name of subject in English** Modern macromolecular engineering materials
**Main field of study (if applicable):** Chemical Engineering and Technology
**Specialization (if applicable):** Advanced Chemical Technologies
**Profile:** academic
**Level and form of studies:** 2nd level studies, full-time
**Kind of subject:** obligatory
**Subject code W03CET-SM2016W, W03CET-SM2016L**
**Group of courses:** NO

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 45 | | |
| Number of hours of total student workload (CNPS) | 75 | | 75 | | |
| Form of crediting (Examination / crediting with grade) | exam | | credit | | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | 3 | | 3 | | |
| including number of ECTS points for practical classes (P) | | | 3 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1,2 | | 1,8 | | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Basic knowledge of polymer chemistry and physical chemistry.

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**SUBJECT OBJECTIVES**

C1 to acquaint students with the current knowledge of advanced polymeric engineering materials
C2 to acquaint students with the properties, methods of production and areas of application of macromolecular compounds
C3 to familiarize students with 3D printing techniques, polymer processing and recycling methods.

**SUBJECT EDUCATIONAL EFFECTS**

**relating to knowledge:**

Student, who has completed the course:
PEU_W01has knowledge of the properties of polymeric engineering materials.
PEU_W02 knows the basic methods of obtaining polymeric engineering materials.
PEU_W03 has knowledge of the application areas of polymeric engineering materials.
PEU_W04 has a basic understanding of advanced macromolecular and composite engineering materials.

**relating to skills:**

Student, who has completed the course:
PEU_U01 is familiar with selected 3D printing techniques
PEU_U02 is able to select the appropriate processing method to obtain the desired product form
PEU_U03 is familiar with selected mechanical and chemical recycling methods for plastics.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours** |
| Lec 1 | Polymeric engineering materials - introduction. | 2 |
| Lec 2 | Processing of polymeric engineering materials. | 2 |
| Lec 3 | Laser modification of polymers. | 2 |
| Lec 4 | Biomedical elastomers. | 2 |
| Lec 5 | Modern natural polymers. | 2 |
| Lec 6 | 3D printing techniques | 2 |
| Lec 7 | Polymer fibers. | 2 |
| Lec 8 | Photoactive polymer materials. | 2 |
| Lec 9 | Polymer recycling. | 2 |
| Lec 10 | Magnetic polymer composites. | 2 |
| Lec 11 | Polymer nanostructures. | 2 |
| Lec 12 | Polymeric materials with ion-exchange properties. | 2 |
| Lec 13 | Polymeric sorbents. | 2 |
| Lec 14 | Forecasts for the development of polymeric engineering materials. | 2 |
| Lec 15 | Summary of lectures and credit colloquium. | 2 |
| | Total hours | **30** |
| **Laboratory** | | **Number of hours** |
| Lab 1 | Introduction, health and safety rules and organizational information | 3 |
| Lab 2 | Object-oriented design and creating details for 3D printing. | 3 |
| Lab 3 | Filament production and FDM 3D printing. | 3 |
| Lab 4 | Application of photoinitiated polymerization in 3D printing. | 3 |
| Lab 5 | Extrusion of multilayer foil. | 3 |
| Lab 6 | Plastic recycling – chemical methods. | 3 |
| Lab 7 | Plastic recycling – mechanical methods. | 3 |
| Lab 8 | Polymer hydrogels. | 3 |
| Lab 9 | Electrospinning of nanofibers. | 3 |
| Lab 10 | Magnetic polimer composites. | 3 |
| Lab 11 | Biomedical elastomers. | 3 |
| Lab 12 | Polymeric porous materials. | 3 |
| Lab 13 | Polymeric materials with ion-exchange properties. | 3 |
| Lab 14 | Polymeric sorbents. | 3 |
| Lab 15 | Making up for not completed exercises. | 3 |
| | Total hours | **45** |

**TEACHING TOOLS USED**

N1. Multimedia presentation
N2. Problem lecture

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| F1 | PEU_U01 – PEU_U03 | Summary reports |
| F2 | PEU_U01 – PEU_U03 | Final test |
| **P1** (lecture) | PEU_W01 – PEU_W04 | Final test |
| **P2** (laboratory) | grade = (F1 + F2) / 2 | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


[1] Elnashar, M., Biopolymers, 2019, IntechOpen.
[2] Han, C.D., Rheology and Processing of Polymeric Materials Volume 2: Polymer Processing, 2006, Oxford University Press
[3] Su W.-F., Principles of Polymer Design and Synthesis, 2013, Springer
[4] Niaounakis, M., Biopolymers: Processing and Products, 2015, Elsevier


**SECONDARY LITERATURE:**


[1] Ji, W. (Ed.), Smart Polymer Hydrogels: Synthesis, Properties and Applications - Volume I, 2023, MDPI


**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**


Konrad Szustakiewicz, Ph.D., prof. PWr, konrad.szustakiewicz@pwr.edu.pl

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY OF CHEMISTRY

**SUBJECT CARD**

| | |
|---|---|
| **Name of subject in Polish:** | **Zaawansowane Technologie Chemiczne – nanotechnologie i energia** |
| **Name of subject in English:** | **Advanced Chemical Technologies – Nanotechnologies and Energy** |
| **Main field of study:** | Chemical Engineering and Technology |
| **Specialization (if applicable):** | Advanced Chemical Technology |
| **Profile**: | academic |
| **Level and form of studies:** | 2nd level, full-time |
| **Kind of subject:** | obligatory |
| **Subject code:** | W03CET-SM2020W, W03CET-SM2020L |
| **Group of courses:** | NO |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 45 | | |
| Number of hours of total student workload (CNPS) | 50 | | 100 | | |
| Form of crediting (Examination / crediting with grade) | exam | | crediting with grade | | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | 2 | | 4 | | |
| including number of ECTS points for practical classes (P) | | | 4 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1,2 | | 1,8 | | |

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1.

**SUBJECT OBJECTIVES**

C1 advanced knowledge mastery by students in the field of nanotechnology, production of nanomaterials, their characterization and applications

C2 familiarizing students with issues related to the use of nanomaterials and nanotechnologies in modern systems of energy production, storage and conversion

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:

PEU_W01 the student has advanced knowledge in the production of modern materials aimed at generating, storing and converting energy

PEU_W02 the student knows the latest trends in the development of nanotechnology

relating to skills:
PEU_U01student is able to plan and carry out nanomaterials production processes
PEU_U02 the student is able to characterize nanomaterials in terms of their suitability for the production and storage of energy and/or fuels
PEU_U03 the student critically processes the acquired information in the field of nanotechnology and nanomaterials
PEU_U04 the student demonstrates the ability to work in a team

relating to social competences:
PEU_K01 the student is ready to critically evaluate his knowledge
PEU_K02 is aware of the importance of technical and non-technical aspects related to the production and use of nanomaterials, also in the context of environmental protection and sustainable development goals

**PROGRAMME CONTENT**

| **Lecture** | | **Number of hours** |
|---|---|---|
| Lec 1 | Nanomaterials: review of synthesis methods, classifications, characterization and applications | 2 |
| Lec 2 | Fullerenes. Synthesis methods, structure, functionalization, properties and applications. | 2 |
| Lec 3 | Nanofibers and carbon nanotubes. Synthesis methods, structure, functionalization, properties and applications | 2 |
| Lec 4 | Graphene and graphene oxide. Synthesis methods, properties and potential applications. | 2 |
| Lec 5 | Metal nanoparticles. Synthesis, characterization, applications. | 2 |
| Lec 6-7 | Ceramic nanomaterials. Synthesis strategies, properties, applications and prospects. | 4 |
| Lec 8-9 | Applications of nanotechnology. The role of nanoscience in the development of societies - Medical applications and health care. Introduction to energy applications. | 4 |
| Lec 10-12 | Nanotechnology in solar cells: applications under development. Nanotechnologies and energy production, storage and conversion. | 6 |
| Lec 13 | Electrocatalysts. Hydrogen production from water. | 2 |
| Lec 14 | Nanomaterials in fuel production technologies | 2 |
| Lec 15 | The future of nanotechnology – summary discussion | 2 |
| | Total hours | **30** |

| **Laboratory** | | **Number of hours** |
|---|---|---|
| La1 | Safety rules for work in the laboratory and rules for passing the course. | 2 |
| La2-La8 | Synthesis and characterization of nanostructures and nanosystems | 20 |
| La9-La14 | Applications of nanostructures and nanosystems | 20 |
| La15 | Summary lab | 3 |
| | Total hours | 45 |

**TEACHING TOOLS USED**

| |
|---|
| N1. Multimedia presentation<br>N2. Discussion<br>N3. Case study<br>N4. Laboratory instructions |

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P (lecture) | PEU_W01-PEU_W02, PEU_K01 PEU_K02 | Exam result (50% of points required to pass) + 10% for activity (possibility of increasing the grade by 0.5) |
| P (laboratory) P=0,7xF1+0,2xF2+0,1xF3 | PEU_U01-PEU_U04, PEU_K01 PEU_K02 | Grades from reports, evaluation of laboratory work, activity |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Nanomaterials for Sustainable Energy Applications, S. P. Kumar, CRC Press Inc. 2023
[2] Nanomaterials: An Introduction to Properties, Synthesis and Applications, E. Craig, Larsen and Keller Education 2019
[3] Nanostructures and Nanomaterials, W. Ying, C. Guozhong, World Scientific Publishing Company 2011


**SECONDARY LITERATURE:**


[1] Specialized literature provided by the teacher at the beginning of the class
[2] Laboratory instructions


**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

Team of lecturers

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY OF CHEMISTRY

**SUBJECT CARD**

**Name of subject in Polish:** Zaawanasowana analiza danych eksperymentalnych
**Name of subject in English:** Advanced analysis of experimental data
**Main field of study (if applicable):** Chemical Engineering and Technology
**Specialization (if applicable): ……..**
**Profile: practical**
**Level and form of studies: 2nd level**
**Kind of subject: optional**
**Subject code** W03CET-SM2102C
**Group of courses: NO**

| | Lecture | Classes | Laboratory | **Project** | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | | 30 | | | |
| Number of hours of total student workload (CNPS) | | 50 | | | |
| Form of crediting (Examination / crediting with grade) | | **Crediting with grade** | | | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | | **2** | | | |
| including number of ECTS points for practical classes (P) | | 2 | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | **1,2** | | | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

**1**. Knowledge of academic courses: mathematical analysis and linear algebra
**2**. Knowledge of the basics of statistics
**3**. Knowledge of Excell
**4**. Knowledge of the principles of presentation of results

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**SUBJECT OBJECTIVES**

**C1**. To indicate the principle of correct elaboration and presentation of research and experimental results
**C2**. To learn advanced statistical methods
**C3**. To learn the practical application of linear regression and correlation
**C4**. To learn the principles of using optimization plans in process optimization
**C5**. To acquire the ability to analyze normality of distribution and homogeneity of variance.
**C6**. To learn the practical application of correlation

**C7.** To learn the methods of analyzing the significance of statistical differences and their interpretation

## SUBJECT EDUCATIONAL EFFECTS

**Relating to knowledge:**

**PEU_W01** - The student defines the basic concepts of statistics
**PEU_W02** - The student knows the principles, objectives and stages of results analysis
**PEU_W03** - Student knows the statistical tests that allow to reject extreme results with large measurement error
**PEU_W04** - Student knows the principles of using linear regression analysis
**PEU_W05** - Student knows the principles of determining normality distribution, homogeneity of variance
**PEU_W06** - Student knows methods of correlation determination
**PEU_W07** - Student knows statistical tests that allow to determine statistically significant differences.

**Relating to skills:**

**PEU_U01** - The student correctly interprets and presents the results
**PEU_U02** - Student is able to reject erroneous results
**PEU_U03** - The student is able to apply linear regression
**PEU_U04** - The student is able to determine normality of the distribution of results and assess homogeneity
**PEU_U05** - Student can determine the relationship between results by using correlation
**PEU_U06** - Student can determine the presence of statistically significant differences
**PEU_U07** - Student can select and apply appropriate statistical tests to assess the significance of statistical differences

**Relating to social competences:**

**PEU_K01** - The student is aware of the need to analyze and process the results
**PEU_K02** - The student is aware of the need to interpret the results and look for relationships between them

## PROGRAMME CONTENT

| | **Classes** | **Number of hours** |
|---|---|---|
| **Cl 1** | Introductory classes. Introduction to statistical processing of results. Significant digits. Measurement error. Graphical presentation of results. | 3h |
| **Cl 2** | Rejection of extreme results. | 3h |
| **Cl 3** | Linear regression. | 3h |
| **Cl 4** | Determination of optimal parameters. | 3h |
| **Cl 5** | Test 1 | 3h |
| **Cl 6** | Analysis of normality of distribution and homogeneity of variance. | 3h |
| **Cl 7** | Correlations | 3h |
| **Cl 8** | Statistically significant differences - comparison of two groups | 3h |
| **Cl 9** | Statistically significant differences - comparison of more than two groups | 3h |
| **Cl 10** | Test 2 | 3h |

| | | |
|---|---|---|
| | **Total hours** | **30h** |

**TEACHING TOOLS USED**

**N1**. Multimedia presentation
**N2**. Computer software - Excel and Statistica
**N3**. Case study
**N4**. Working with the results
**N5**. Problem-based lecture
**N6**. Own work

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| F1 | PEU_W01-W04,<br>PEU_U01-U03<br>PEU_K01-K02 | Test 1 |
| F2 | PEU_W04-W07<br>PEU_U04-U07<br>PEU_K01-K02 | Test 2 |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

[1] Frost J.:Introduction to Statistics: An Intuitive Guide for Analyzing Data and Unlocking Discoveries, 2020
[2] Frost J.: Regression Analysis: An Intuitive Guide for Using and Interpreting Linear Models, 2020
[3] Carlberg C.: Statistical Analysis: Microsoft Excel, 2017
[4] de Smith M.: Statistical Analysis Handbook, 2018

**SECONDARY LITERATURE:**

[1] Cowan G.: Statistical Data Analysis (Oxford Science Publications), 1997
[2] www.statsoft.pl

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

**Dr inż. Grzegorz Izydorczyk, grzegorz.izydorczyk@pwr.edu.pl**

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY CHEMISTRY

**SUBJECT CARD**

**Name of subject in Polish** Biokataliza w przemyśle spożywczym, browarniczym i farmaceutycznym
**Name of subject in English** Biocatalysis in food, brewery and pharmaceutical industry
**Main field of study (if applicable):** Chemical Engineering and Technology
**Specialization (if applicable):** Advanced Chemical Engineering
**Profile:** academic
**Level and form of studies:** 2nd level
**Kind of subject:** obligatory
**Subject code** W03CET-SM2007W, W03CET-SM2007L, W03CET-SM2007S
**Group of courses** NO

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 15 | | 45 | | 15 |
| Number of hours of total student workload (CNPS) | 50 | | 75 | | 25 |
| Form of crediting (Examination / crediting with grade) | exam | | crediting with grade | | crediting with grade |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | **2** | | 3 | | 1 |
| including number of ECTS points for practical classes (P) | | | 3 | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0,6 | | 1,8 | | 0,6 |

**1w+3l +1s (2+3+1 ECTS).**

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1.Fundamentals of physical chemistry
2 Fundamentals of chemical engineering

**SUBJECT OBJECTIVES**

C1 To become familiar with the concepts of industrial biotechnology.
C2 To become familiar with methods of obtaining and characterising bioproducts.
C3 To become familiar with the possible applications of enzyme and microorganism in food, brewery and pharmaceutical industry.

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
PEU_W01 Knows the concepts of industrial biotechnology.
PEU_W02 Has knowledge of methods of obtaining bioproducts.
PEU_W03 Has knowledge of techniques for biocatalysis in industry.
PEU_W04 Knows the applications of industrial biotechnology in various fields

relating to skills:
PEU_U01 Can select a method and synthesise a chosen bioporoduct.
PEU_U02 Can carry out investigations of bioproduct properties and their characterisation using specialised equipment
PEU_U03 Can analyse and process the obtained test results
PEU_U04 Can find in literature the information about bioprocesses and present them to another students.

relating to social competences:
PEU_K01 Is able to cooperate in a laboratory group
PEU_K02 Feels responsible for the results of the assigned task

**PROGRAMME CONTENT**

| **Lecture** | | **Number of hours** |
|---|---|---|
| Lec 1 | Biocatalysis in food industry: dairy, bakery. | 2 |
| Lec 2 | Production of protein and peptide preparations. | 2 |
| Lec 3 | Organic acid production | 2 |
| Lec 4 | fermented beverage industry | 2 |
| Lec 5 | vaccine production | 2 |
| Lec 6 | antibiotics production | 2 |
| Lec 7 | production of enzyme preparations | |
| Lec 8 | Written course credit | 1 |
| | Total hours | **15** |

production of food supplements

| **Laboratory** | | **Number of hours** |
|---|---|---|
| La1 | Analytical methods for monitoring biocatalytic processes | 5 |
| La2 | Beer production – part 1 | 5 |
| La3 | Enzymatic catalysis - determination of reaction kinetic parameters | 5 |
| La4 | Production of an immobilized biocatalyst of industrial importance | 5 |
| La5 | Production of lactose-free milk | 5 |
| La6 | Cold pasteurization of milk using catalase | 5 |
| La7 | Hydrolysis of penicillin G in a stirred batch reactor | 5 |
| La8 | Selection of the degree of conversion of D-glucose to D-fructose in a packed bed column (immobilized enzyme) | 5 |
| La9 | Beer production – part 2 | 5 |
| | Total hours | 45 |

| **Seminar** | | **Number of hours** |
|---|---|---|
| Se1 | Biocatalysis in food industry | 6 |

| | | |
|---|---|---|
| Se2 | Biocatalys in brewery and winery. | 3 |
| Se3 | Biocatalysis in pharmaceutical industry. | 6 |
| | Total hours | 15 |

| TEACHING TOOLS USED |
|---|
| N1. Lecture with multimedia presentation<br>N2. Laboratory instructions<br>N3. Laboratory workstations<br>N4. Students presentation. |

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P (lecture) | PEU_W01<br>PEU_W02<br>PEU_W03<br>PEU_W04 | Credit test |
| F1 (laboratory)<br><br>P=F1 | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01<br>PEU_K02 | Laboratory exercise reports (arithmetic mean) |
| P (seminar) | PEU_U04 | presentation |
| 3.0 jeżeli 3.00 ≤ P < 3.25<br>3.5 jeżeli 3.25 ≤ P < 3.75<br>4.0 jeżeli 3.75 ≤ P < 4.25<br>4.5 jeżeli 4.25 ≤ P < 4.75<br>5.0 jeżeli 4.75 ≤ P | | |

| PRIMARY AND SECONDARY LITERATURE |
|---|
| **PRIMARY LITERATURE:** |
| [1] V.Beschkov, D.Yankov, Downstream Processing in Biotechnology, De Gruyter 2021<br><br>[2] N.Dunford, Food and Industrial Bioproducts and Bioprocessing, Iowa State University Press 2020 |
| **SECONDARY LITERATURE:** |
| [3] PDF presentation |
| **SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)** |
| **Anna Trusek,** anna.trusek@pwr.edu.pl |

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY OF CHEMISTRY

**SUBJECT CARD**

**Name of subject in Polish** Optymalizacja i zarządzanie procesami chemicznymi
**Name of subject in English** Chemical Process Optimisation and Management
**Main field of study (if applicable):** Chemical Engineering and Technology
**Specialization (if applicable):** Advanced Chemical Engineering.
**Profile: academic / practical***
**Level and form of studies: 2nd level, full-time / part-time***
**Kind of subject: obligatory**
**Subject code** W03CET-SM2011W, W03CET-SM2011P
**Group of courses NO**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 15 | | | 60 | |
| Number of hours of total student workload (CNPS) | 50 | | | 100 | |
| Form of crediting (Examination / crediting with grade) | crediting with grade | | | crediting with grade | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | 2 | | | 4 | |
| including number of ECTS points for practical classes (P) | | | | 4 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0,6 | | | 2,4 | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Basic knowledge of unit processes and equipment solutions in chemical engineering and technology.
2. Basic knowledge of chemical process design.
3. Basic knowledge and skills in the field of computer-aided design and optimization of chemical processes

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**SUBJECT OBJECTIVES**

C1. Obtaining basic knowledge about designing industrial installations and managing the manufacturing process
C2. To familiarize students with the concepts of production economics.
C3. Understanding and practical application of knowledge about modeling and optimization of chemical processes
C4. Understanding the principles of developing project documentation.
C5. Understanding the principles of integrated process design.
C6. Acquiring the ability to present work results.
C7. Acquiring the ability to use specialized computer software to design and optimize chemical processes

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:

PEU_W01 – Has basic knowledge of designing industrial installations and managing the manufacturing process

PEU_W02 – Has the knowledge needed to develop an economic analysis of an industrial installation used to obtain a product with the required parameters.

PEU_W03 – Knows methods of optimizing unit processes and technological lines.

relating to skills:

PEU_U01 – Is able to prepare basic design documentation.

PEU_U02 – Is able to perform process optimization calculations.

PEU_U03 – Is able to select a sequence of unit operations for a technological process.

PEU_U04 – Is able to make an economic analysis of a chemical installation.

PEU_U05 – Is able to use selected computer programs to design and optimize industrial installations

PEU_U06 – Is able to present the goals and results of scientific work in the form of an oral presentation using modern information and communication techniques.

relating to social competences:

PEU_K01 – Is ready to act and think in an entrepreneurial way.

PEU_K02 – Is able to cooperate in a project group.

PEU_K03 – Is able to present the results of work.

**PROGRAMME CONTENT**

| **Lecture** | | **Number of hours** |
|---|---|---|
| Lec 1 | Design basics | 2 |
| Lec 2 | Mass and energy balances | 2 |
| Lec 3 | Technical drawings | 2 |
| Lec 4 | Technological diagrams and control and measurement equipment | 2 |
| Lec 5 | Modeling and optimization | 2 |
| Lec 6 | Cost estimates and management | 2 |
| Lec 7 | Waste management | 2 |
| Lec 8 | Test | 1 |
| | Total hours | **15** |

| **Classes** | | **Number of hours** |
|---|---|---|
| Cl 1 | | |
| Cl 2 | | |
| Cl 3 | | |
| Cl 4 | | |
| .. | | |
| | Total hours | |

| **Laboratory** | | **Number of hours** |
|---|---|---|
| Lab 1 | | |
| Lab 2 | | |

| | | |
|---|---|---|
| Lab 3 | | |
| Lab 4 | | |
| Lab 5 | | |
| … | | |
| | Total hours | |

| **Project** | | **Number of hours** |
|---|---|---|
| *Part I* | | |
| Pr1 | Analysis of the selected technology and presentation of the process concept. Presentation of the schematic diagram and mass balance. | 4 |
| Pr2 | Development of the process flow diagram and selection of control and measurement equipment | 4 |
| Pr3 | Process modeling and optimization. | 4 |
| Pr4 | Preparation of an executive or assembly drawing of one of the devices used (or its parts) | 4 |
| Pr5 | Development of a spatial layout diagram,, installation view. Preparation of a piping and instrumentation diagram | 4 |
| Pr6 | Preparation of cost estimate | 4 |
| Pr7 | Preparation of a multimedia presentation. Presentation rules | 4 |
| *Part II* | | |
| Pr8 | SuperProdesigner introduction. | 4 |
| Pr9 | Process timeline. Up-stream and down-stream processes | 4 |
| Pr10 | Order and costs of processes. | 4 |
| Pr11 | Membrane processes. Diffusion processes. | 4 |
| Pr12 | Gantt graphs. Resources management. Economical analysis. | 4 |
| Pr13 | Optimal process parameters. Optimalisation of construction. | 4 |
| Pr14 | Bottlenecks. Environmental impact of designed proces. | 4 |
| *Final part* | | |
| Pr15 | Project defenses (part 1 and 2) | 2+2 |
| | Total hours | 60 |

| **Seminar** | | **Number of hours** |
|---|---|---|
| Semin 1 | | |
| Semin 2 | | |
| Semin 3 | | |
| … | | |
| | Total hours | |

**TEACHING TOOLS USED**

N1. Lecture with multimedia presentation.
N2. Preparation and presentation of the project.
N3. Preparation of design documentation using computer program packages.
N4. Use of specialized software to create projects
N5. Consultations

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| F1(Lecture) | PEU_W01 - PEU_W03 | Test |
| P1 = F1 | | P1 = F1 |
| F2 (proj. Part I) | PEU_U01 - PEU_U06<br>PEU_K01 - PEU_K06 | Completed project |
| F3 (proj. Part II) | PEU_U01 - PEU_U06<br>PEU_K01 - PEU_K06 | The project made using specialized software |
| P2 = (F2+F3)/2 | | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] B. Sujak-Cyrul, Quality management systems: an introduction to the project of documenting and audit of quality management systems, Wrocław, Wrocław University of Technology; Łódź: PRINTPAP, 2011.
[2] S.E. Windsor, An introduction to green process management, Milwaukee, Wis.: ASQ Quality Press, cop. 2011.
[3] F.N. Fraser, Global engineering economics, Financial decision making for engineers, 4th Ed., Prentice Hall, Toronto, 2009.
[4] E. Heinzle, A.P. Biwer, C.L. Cooney - Development of Sustainable Bioprocesses: Modeling and Assessment, Viley 2006.
[5] L.T. Blank, A. Tarquin, Engineering Economy, 6th Ed., McGraw-Hill, Boston, 2005.
[6] R. Turton, R. C. Bailie, W. B. Whiting, J. A. Shaeiwitz, D. Bhattacharyya, Analysis, Synthesis and Design of Chemical Processes, 4th Edition, Prentice Hall, 2012.
[7] W.D. Seider, D.R. Lewin, J.D. Seader, S. Widagdo, R. Gani, K- Ming. Ng, Product and Process Design Principles: Synthesis, Analysis and Evaluation, 4th Edition, Wiley, 2016.


**SECONDARY LITERATURE:**


[1] Woodard & Curran, Inc., Industrial Waste Treatment Handbook, Elsevier, 2006.
[2] H.V. Mott, Environmental Process Analysis: Principles and Modeling, Wiley, 2013.
[3] R.G. Harrison, P. Todd, S.R. Rudge, D.P. Petrides - Bioseparations Science and Engineering, Oxford, 2002.
[4] SuperPro Designer user manual.


## SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)


dr inż. Konrad Matyja, konrad.matyja@pwr.edu.pl

dr inż. Michał Araszkiewicz, michal.araszkiewicz@pwr.edu.pl

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

**SUBJECT CARD**

**Name of subject in Polish** Projektowanie procesów chemicznych z użyciem obliczeń CFD
**Name of subject in English** Chemical Process Project with CFD calculations
**Main field of study (if applicable):** Chemical Engineering and Technology
**Specialization (if applicable):** Advanced Chemical Engineering
**Profile: academic ~~/ practical~~***
**Level and form of studies: ~~1st/~~ 2nd level, ~~uniform magister studies~~*, full-time ~~/ part-time~~***
**Kind of subject: obligatory ~~/ optional / university-wide~~***
**Subject code W03CET-SM2006W, W03CET-SM2006P**
**Group of courses ~~YES~~ / NO***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 15 | | | 60 | |
| Number of hours of total student workload (CNPS) | 50 | | | 100 | |
| Form of crediting (Examination / crediting with grade) | crediting with grade | | | crediting with grade | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | 2 | | | 4 | |
| including number of ECTS points for practical classes (P) | | | | 4 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.6 | | | 2,4 | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Knowledge of mathematics at a level that allows to understand the transport equations in single- and multi-phase systems, with laminar and turbulent flow
2. Knowledge of the fundamentals of momentum, heat and mass transfer in chemical devices

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**SUBJECT OBJECTIVES**

C1. Acquainting students with the basics of CFD methods and their areas of application
C2. Acquire basic skills to perform CFD calculations of momentum, heat and mass transfer in laminar and turbulent flow, in single and multiphase, steady and transient systems, with the help of a selected software package
C3. Acquiring basic skills in the design and optimization of apparatus construction used in the chemical industry using CFD methods
C4. Familiarization with modern programs for simulation and design of chemical installations
C5. Teaching how to perform simulation calculations and design of chemical installations
C6. Teaching how to search and process calculation results

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
PEU_W01 - knows the principles of building mathematical models of processes and solving them using CFD methods
relating to skills:

PEU_U01 - can build a mathematical model of the process and perform simulation calculations using specialized software
PEU_U02 - is able to perform design calculations of selected unit operations with the use of specialized software
relating to social competences:
PEU_K01 - can work in a group

## PROGRAMME CONTENT

| Lecture | | Number of hours |
|---|---|---|
| Lec1 | Familiarization with the basics of CFD methods, their advantages and disadvantages, area of application | 1 |
| Lec2 | Presentation of the equations of momentum, heat and mass transport of a Newtonian fluid for laminar one phase flow. | 1 |
| Lec3 | Definition of turbulence, different approaches to the description of turbulent flows | 1 |
| Lec4 | Presentation of turbulence models | 1 |
| Lec5 | Different ways of describing the boundary zone | 1 |
| Lec6 | Presentation of numerical basics of methods for solving momentum, heat and mass transport equations (difference and finite element methods, control volume method) | 1 |
| Lec7 | Interpolation Schemes and pressure calculation | 1 |
| Lec8 | Description of boundary conditions | 1 |
| Lec9 | Numerical mesh (different types and ways of generation) | 1 |
| Lec10 | Methods for evaluating and improving the quality of the numerical mesh | 1 |
| Lec11 | General classification of multiphase models | 1 |
| Lec12 | VOF and Level Set models | 1 |
| Lec13 | Euler-Euler and Euler-Lagrange models | 1 |
| Lec14 | Selection of a multiphase model | 1 |
| Lec15 | Selection of the right computer hardware for CFD calculations | 1 |
| | Total hours | **15** |
| **Project** | | **Number of hours** |
| Pr1 | Introduction. Flash simulation. | 2 |
| Pr2 | Distillation process simulation | 2 |
| Pr3 | Sensitivity analysis | 2 |
| Pr4 | Design specification | 2 |
| Pr5 | Physical property analysis | 2 |
| Pr6 | Physical property estimation | 2 |
| Pr7 | Detailed design of heat exchanger | 2 |
| Pr8 | Test I | 2 |
| Pr9 | Chemical reactor simulation | 2 |
| Pr10 | Chemical plant optimization | 2 |

| | | |
|---|---|---|
| Pr11 | Design of distillation column | 2 |
| Pr12 | Parameter regression | 2 |
| Pr13 | Analysis of heat exchanger network | 2 |
| Pr14 | Synthesis of heat exchanger network | 2 |
| Pr15 | Test II | 2 |
| Pr16 | Basic information about the CFD package user interface, navigating in the program, solving a simple laminar flow example in a pipe, creating simple geometry, generating a mesh, defining boundary conditions | 2 |
| Pr17 | Simulation of a single-phase laminar flow in different chemical devices in 2D, 2D axisymmetric and 3D geometry, comparison of results | 2 |
| Pr18 | Simulation of a single-phase turbulent flow in various chemical devices in 2D, 2D axisymmetric and 3D geometry, application of different turbulence models, comparison of results | 2 |
| Pr19 | Simulation of the heat conduction in various chemical apparatuses | 2 |
| Pr10 | Simulation of the heat conduction with convection and radiation in various chemical apparatuses | 2 |
| Pr21 | Simulation of a flow with diffusion and chemical reaction | 2 |
| Pr22 | Simulation of a one phase isothermal, unsteady flow | |
| Pr23 | Simulation of a one phase transient flow with heat transfer | 2 |
| Pr24 | Simulation of a multiphase flow with the use of VOF model | 2 |
| Pr125 | Simulation of a gas-solid flow with the use of Euler-Euler model | 2 |
| Pr26 | Simulation of a liquid-liquid flow with the use of Euler-Euler model | 2 |
| Pr27 | Determination of particle trajectories in a multiphase flow using the Euler-Lagrange model | 2 |
| Pr28 | Project of the optimalization of a jet pump by means of CFD methods | 2 |
| Pr29 | Project of the optimalization of a heat exchanger by means of CFD methods | 2 |
| Pr30 | Test III | 2 |
| | Total hours | **60** |

| **TEACHING TOOLS USED** |
|---|
| N1. Lecture with multimedia presentation<br>N2. Computer simulation |

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P (lecture) | PEU_W01 | Final examination |
| F1 | PEU_U01<br>PEU_U02<br>PEU_U03 | Test I |
| F2 | PEU_U01<br>PEU_U02<br>PEU_U03 | Test II |
| F3 | PEU_U01 | Test III |
| F4 | PEU_U01<br>PEU_U02<br>PEU_U03<br><br>PEU_K01 | Evaluation of the project |

P = (F1 + F2 + F3+F4)/4 Each test and project must be passed with a positive grade.

3,0 if 3,00 ≤ P < 3,25

3,5 if 3,25 ≤ P < 3,75

4,0 if 3,75 ≤ P < 4,25

4,5 if 4,25 ≤ P < 4,75

5,0 if 4,75 ≤ P

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] [1] J. D. Anderson, Computational Fluid Dynamics: The Basics with Application, McGraw-Hill, New York 1995

[2] [2] R. Shefflan, Teach Yourself the Basics of AspenPlus, John Wiley & Sons, 2011


**SECONDARY LITERATURE:**


[1] Ansys Fluent Help

[2] Comsol Multiphysics Help

[3] R. Smith, Chemical Process Design and Integration, Wiley 2005 R. Turton et al., Analysis, Synthesis, and Design of Chemical Processes, Prentice Hall 2009


**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**


(Wojciech Ludwig, wojciech.ludwig@pwr.edu.pl)

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

**SUBJECT CARD**

**Name of subject in Polish** Aparaty inżynierii chemicznej

**Name of subject in English** Chemical Processes Equipment

**Main field of study (if applicable):** Chemical Engineering and Technology

**Specialization (if applicable):** Advanced Chemical Engineering

**Profile: academic / ~~practical~~***

**Level and form of studies: ~~1st/~~ 2nd level~~, uniform magister studies~~*, full-time ~~/ part-time~~***

**Kind of subject: obligatory ~~/ optional / university-wide~~***

**Subject code** W03CET-SM2001W, W03CET-SM2001P

**Group of courses ~~YES /~~ NO***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 15 | | | 60 | |
| Number of hours of total student workload (CNPS) | 50 | | | 100 | |
| Form of crediting (Examination / crediting with grade) | E | | | crediting with grade | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | 2 | | | 4 | |
| including number of ECTS points for practical classes (P) | | | | 4 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0,6 | | | 2,4 | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Fundamentals of physics and general chemistry.
2. Understanding of energy, power, heat and mass transfer concepts.
3. Understanding of thermodynamics rules.
4. Basics of calculus.
5. Knowledge of the international system of units (SI).
6. Knowledge of the principles of technical drawing.
7. The ability to use AutoCAD.

**SUBJECT OBJECTIVES**

C1 Acquaintance student with technological process, apparatus and equipment being part of chemical installation.

C2. Gaining by the student the basic knowledge on the work of the process equipment applied for material transportation, heat and mass transfer.

C4. Acquaintance students with the apparatus for measurement, and manual and automatic control, applied in chemical installations.

C5. Presentation of methods for searching for, processing and analyzing calculation results.

C6. Familiarization of the student with the principles of creating and reading technological schemes.

C7. The ability to use computer-aided design in the creation and modification of technological schemes.

C8. Introduction to modern software for the simulation and design of chemical plants.

C9. Acquainting with the construction of unit operations and chemical plant models.
C10. Teaching how to perform simulation and design calculations.
C11. Teaching the search and processing of obtained calculation results.

**SUBJECT EDUCATIONAL EFFECTS**

**relating to knowledge:**

PEU_W01 – knows what the technological process, production installation, and what role the different apparatus play in the process installation.
PEU_W02 – knows basic equipment applied in the chemical industry installation.
PEU_W03 – knows fundamentals of design of unit operations and selection of the apparatus and constructional materials.
PEU_W04 – knows the rules of the measurement and control equipment selection as well as safety rules applied for chemical installations.

**relating to skills:**

PEU_U01– Can create and read a technological scheme.
PEU_U02 – Can use the methods of computer aided design in the creation and modification of technological schemes.
PEU_U03 – Can perform sensitivity analyses, optimisation calculations and set design specifications.
PEU_U04 – Can build a mathematical process model and perform simulation calculations using professional software
PEU_U05 – Can perform design calculations of selected unit operations
PEU_U06 – Can determine the physicochemical properties of substances and phase equilibria

**relating to social competences:**

PEU_K01 – can discuss the problems of the work conditions and equipment selection for chemical technology installation.
PEU_K02 – can work in a team.
PEU_K03 – can appreciate the quality of an experimental result ;
PEU_K04 – can evaluate critically the veracity of statistical analysis of any data.

**PROGRAMME CONTENT**

| **Lecture** | | **Number of hours** |
|---|---|---|
| Lec1 | Technological process. Unit processes and unit operations. Scheme of a technological system. Rules of the equipment selection. Equipment for raw materials, semi-products, products, and wastes storage. | 2 |
| Lec2 | Means of transport for the materials. Friction losses during the process of fluids transportation in the pipelines. | 2 |
| Lec3 | Equipment for grinding, mixing, sedimentation, filtration and spinning. | 2 |
| Lec4 | Equipment for heat transfer. | 2 |
| Lec5 | Equipment for evaporation and liquid solutions concentration. | 2 |
| Lec6 | Equipment for absorption and distillation. | 2 |
| Lec8 | Equipment for extraction and adsorption. | 2 |
| Lec9 | Exam. | 1 |
| | Total hours | 15 |

| **Project** | **Number of hours** |
|---|---|

| Industrial plant engineering and design | | |
|---|---|---|
| Pr1 | Introduction into the environment of AutoCAD Plant 3D. Familiarization with the user interface. Creating and managing a project in AutoCAD Plant 3D. Files management. Familiarization with the different work spaces. | 2 |
| Pr2 | Working with the specification editor and part catalog - AutoCAD Plant 3D Spec Editor. | 2 |
| Pr3-4 | P&ID drawing - creating a design and a technological drawing in 2D. Inserting process equipment into the installation diagram. Pipelines. Adding fittings. Adding descriptions to the technological drawing. | 4 |
| Pr5-6 | Industrial plant 3D Project - modeling of steel constructions | 4 |
| Pr7 | Industrial plant 3D Project - addition and configuration of process equipment | 2 |
| Pr8-9 | Industrial plant 3D Project - connecting equipment with pipelines, addition of fittings. | 4 |
| Pr10-11 | Documentation - creating and printing 2D documentation in AutoCAD Plant 3D. | 4 |
| Pr12-13 | Design data management and reporting in AutoCAD Plant 3D. Data exchange with other applications - AutoCAD, Inventor Professional, Excel. | 4 |
| Pr14 | Preparation of final projects | 2 |
| Pr15 | Presentation and submission of the final project documentation in AutoCAD Plant 3D. | 2 |
| | Sum of hours | **30** |

| **Project** | | **Number of hours** |
|---|---|---|
| **Calculation and optimisation of unit processes** | | |
| Pr1 | Presentation of the principles for completing the course. Discussion of the use of simulation software in chemical and process engineering. Introduction to the Aspen Plus interface. | 2 |
| Pr2 | Principles of proper selection of physical property models. | 2 |
| Pr3-4 | Sensitivity analysis and design specifications. | 4 |
| Pr5-6 | Analysis and estimation of physicochemical properties of pure components and mixtures. | 4 |
| Pr7 | Test 1 | 2 |
| Pr8 | Basics of hydraulic calculations. Calculation of pressure drops in pipelines. Simulation of the operation of media displacement devices. The cavitation issue. | 2 |
| Pr9 | Determination of properties of solid materials, including granular materials. Simulation of the separation of solid materials. | 2 |
| Pr10 | Simulation of equilibrium distillation and rectification. | 2 |
| Pr11 | Simulation of the extraction process. | 2 |
| Pr12 | Types of chemical reactors. Simulation of the operation of chemical reactors. | 2 |

| | | |
|---|---|---|
| Pr13 | Elements of heat exchanger calculations - an introduction to Aspen Exchanger Design and Rating. | 2 |
| Pr14 | Optimisation of the chemical installation | 2 |
| Pr15 | Test 2 | 2 |
| | Sum of hours | **30** |

**TEACHING TOOLS USED**

N1. Lecture.
N2. Multimedia presentation.
N3. AspenPlus simulation and design software
N4. Aspen Exchanger Design and Rating program for simulation and design of heat exchangers
N5. Aspen Properties program for calculating physicochemical properties of fluids and phase equilibria
N6. Microsoft Excel program for calculation of basic unit processes
N7. Individual work in simulation software.
N8. Using Autodesk Plant 3D software, AutoCAD, Autodesk Inventor.
N9. Preparing the project.

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P=F1 (Lecture) | PEU_W01<br>PEU_W02<br>PEU_W03<br>PEU_W04 | Exam |
| P=F2 (Project) | PEU_U01<br>PEU_U02<br>PEU_K01- PEU_K04 | Project preparation |
| P=F3 (Project) | PEU_U03<br>PEU_U04<br>PEU_U05<br>PEU_U06<br>PEU_K01- PEU_K04 | Test 1<br>Test 2<br>Project preparation |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


[1] Green D.W. i Perry R.H., *Perry's Chemical Engineers' Handbook*. McGraw-Hill, 2008.
[2] Couper J., Penney W., Fair J. i Walas S.M., *Chemical engineering equipment – selection and design*. 3rd edition. Elsevier, 2012.
[3] Tickoo S., AutoCAD Plant 3D 2023 for Designers, ADCIM Technologies; 7th edition, 2022.
[4] Toghraei M., Piping and Instrumentation Diagram Development, Wiley-Aiche, 2019.
[5] R. Shefflan, Teach Yourself the Basics of AspenPlus, John Wiley & Sons, 2011.


**SECONDARY LITERATURE:**


[6] Tutorial Books, Introduction to AutoCAD Plant 3D 2019, Tutorial Books, 2018.

[7] R. Smith, *Chemical Process Design and Integration*, Wiley 2005.
[8] K. Al-Malah, Aspen Plus® Chemical Engineering Applications, Wiley, Hoboken, 2017.
[9] J. Haydary, Chemical Process Design and Simulation: Aspen Plus and Aspen Hysys Applications, Wiley, 2019.

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

Halina Maniak, halina.maniak@pwr.edu.pl
Justyna Ulatowska, justyna.ulatowska@pwr.edu.pl
Mateusz Kruszalnicki, mateusz.kruszelnicki@pwr.edu.pl

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

**SUBJECT CARD**

**Name of subject in Polish …Reaktory chemiczne i bioreaktory…….**
**Name of subject in English ……Chemical reactors and bioreactors…….**
**Main field of study (if applicable): …Chemical engineering and technology…….**
**Specialization (if applicable): …Advanced Chemical Technologies…..**
**Profile: academic**
**Level and form of studies: 2nd level**
**Kind of subject: obligatory**
**Subject code** W03CET-SM2018W, W03CET-SM2018P
**Group of courses NO**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 15 | | | 30 | |
| Number of hours of total student workload (CNPS) | 25 | | | 50 | |
| Form of crediting (Examination / crediting with grade) | Exam | | | crediting with grade | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | 1 | | | 2 | |
| including number of ECTS points for practical classes (P) | | | | 2 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0,6 | | | 1,2 | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Knowledge of mathematics, physics, and mass transfer phenomena at the bachelor's level (chemical engineering or related)
2. Knowledge of the basics of chemical reactor engineering

**SUBJECT OBJECTIVES**

C1 To familiarize students with the topic and design of heterogeneous chemical reactors (non-catalytic reactions)
C2 To introduce students to the topic of heterogeneous catalysis
C3 To familiarize students with the design of heterogeneous catalytic reactors
C4 To introduce students to the topic and design of bioreactors

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
PEU_W01 – student knows the principles of designing chemical reactors for heterogeneous non-catalytic processes
PEU_W02 - student knows the principles of designing chemical reactors for heterogeneous catalytic processes

PEU_W03 - student knows the principles of design and operation of bioreactors

relating to skills:
PEU_U01 – student is able to determine the limiting resistance of the process in non-catalyzed heterogeneous processes and derive the process rate equation
PEU_U02– student is able to determine the limiting resistances in heterogeneous catalytic processes and derive the process rate equation
PEU_U03 – student can calculate the volume, reaction or residence time, or conversion in heterogeneous chemical reactors and bioreactors.

**PROGRAMME CONTENT**

| **Lecture** | | **Number of hours** |
|---|---|---|
| Lec 1 | Optimal temperature regime | 2 |
| Lec 2 | Heterogeneous reactions | 1 |
| Lec 3 | Gas-liquid and liquid-liquid reaction systems | 1 |
| Lec 4 | Gas-solid non-catalytic systems | 1 |
| Lec 5 | Heterogeneous catalysis and catalytic kinetics | 1 |
| Lec 6 | Heterogeneous catalytic reactor design | 1 |
| Lec 7 | External diffusion effects in heterogeneous catalytic reactions | 1 |
| Lec 8 | Diffusion and reaction in porous catalyst | 1 |
| Lec 9 | Slurry reactors | 1 |
| Lec 10 | Enzymatic reaction fundamentals – Enzyme-Substrate Complex, Mechanisms, Michaelis-Menten Equation. Batch reactor design. | 1 |
| Lec 11 | Inhibition of enzyme reactions: competitive, uncompetitive, mixed, and substrate inhibition. Continuous stirred tank reactor. | 1 |
| Lec 12 | Microbial fermentation. | 1 |
| Lec 13 | Substrate-limiting microbial fermentation. Bioreactor design. | 1 |
| Lec 14 | Product-limiting microbial fermentation. Bioreactor design. | 1 |
| | Total hours | 15 |

| **Project** | | **Number of hours** |
|---|---|---|
| Proj 1 | Multiple heterogeneous reactions – isothermal performance, process design | 2 |
| Proj 2 | Multiple heterogeneous reactions – non-isothermal performance, process design | 2 |
| Proj 3 | Packed bed reactor; pressure drop | 2 |
| Proj 4 | Optimal temperature regime for catalytic reactor – exothermic reactions | 4 |
| Proj 5 | Optimal temperature regime for catalytic reactor – endothermic reactions | 2 |
| Proj 6 | Absorber design (chemisorption) | 3 |
| Proj 7 | Gas-solid non-catalyzed system design | 2 |
| Proj 8 | Catalytic reactions – determination of the process rate and reactor design | 3 |

| | | |
|---|---|---|
| Proj 9 | Catalytic reactor design – external diffusion effects | 2 |
| Proj10 | Catalytic reactor design – diffusion in porous catalyst | 2 |
| Proj11 | Enzymatic reactions – bioreactor design | 3 |
| Proj12 | Microbial fermentation – bioreactor design | 3 |
| | Total hours | 30 |

**TEACHING TOOLS USED**

N1. Multimedia presentation
N2. Polymath and Matlab software
N3. MS Office (Excel)

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| F (project) | PEU_U01 – U03 | Exam |
| P (lecture) | PEU_W01 -W03 | Exam |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


[1] S. Fogler, Elements of Chemical Reaction Engineering, 6th Edition, Pearson, 2020.

[2] S. Fogler, Essentials of Chemical Reaction Engineering, 2nd Edition, Pearson, 2018.

[3] O. Levenspiel: Chemical Reaction Engineering, 3rd edition, John Wiley & Sons, New Jersey, 1999.


**SECONDARY LITERATURE:**


[1] I. Zizovic, Chemical Reaction Engineering with MATLAB examples, Irena Zizovic, Script, Politechnika Wrocławska, 2019.


**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**


**Irena Žižović (irena.zizovic@pwr.edu.pl)**

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of CHEMISTRY

**SUBJECT CARD**

**Name of subject in Polish** Sensory chemiczne i biosensory – podstawy i zastosowanie
**Name of subject in English** Chemical sensors and biosensors - fundamentals and applications
**Main field of study (if applicable):** Chemical Engineering and Technology
**Specialization (if applicable):** Advanced Chemical Technologies
**Profile:** academic
**Level and form of studies:** 2nd level, full-time
**Kind of subject:** obligatory
**Subject code: W03CET-SM2017W, W03CET-SM2017L**
**Group of courses:** NO

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 15 | | 30 | | |
| Number of hours of total student workload (CNPS) | 25 | | 50 | | |
| Form of crediting (Examination / crediting with grade) | passing with a grade | | passing with a grade | | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | **1** | | **2** | | |
| including number of ECTS points for practical classes (P) | 0 | | 2 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0,6 | | 1,2 | | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Knowledge in the field of inorganic, analytical, physical, organic chemistry, and physics.
2. Basic knowledge of instrumental analytical techniques.
3. Fundamental skills in analytical techniques

**SUBJECT OBJECTIVES**

C1. Familiarizing students with the mechanisms of operation of chemical and biosensors, as well as the detection methods used in sensing.
C2. Introducing students to the physicochemical fundamentals of the construction of chemical and biosensors.
C3. Providing students with an understanding of the potential applications of chemical and biosensors as analytical tools in medical diagnostics, bioanalytics, food analysis, and environmental protection.

## SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01: Knows the definitions of a sensor and biosensor and has knowledge regarding the classification of sensors based on their operating principle and method of analyte detection.

PEU_W02: Understands the principles of operation (detection) of electrochemical, optical, mass, thermal, and piezoelectric sensors.

PEU_W03: Knows the receptor elements in a sensor device, understands their operation principles in various types of sensors and biosensors.

PEU_W04: Familiar with the analytical parameters of sensors and biosensors, and knows their application possibilities as analytical tools in various industries, environmental protection, and broad diagnostics.

relating to skills:

PEU_U01: Can safely conduct oneself during laboratory work.

PEU_U02: Can correctly carry out a planned experiment.

PEU_U03: Can apply instrumental techniques in designing and creating a simple analytical system.

PEU_U04: Can prepare a written report on a conducted experiment, analyze the obtained results, and draw valid conclusions.

relating to social competences:

PEU_K01: Can collaborate in a group during laboratory sessions.

PEU_K02: Is ready to effectively organize one's work, critically assess the knowledge possessed, and evaluate the progress of tasks being carried out.

## PROGRAMME CONTENT

| | Lecture | Number of hours |
|---|---|---|
| Lec 1 | Definition of a sensor and a biosensor. General characteristics and structure of a sensor and a biosensor. Application of sensors. Types of chemical sensors. Classification of biosensors based on the classical operating principle. Discussion of course grading principles. | 1 |
| Lec 2 | Fundamentals of chemical sensing - operational parameters of sensors: measurement range, detection limits, sensitivity, selectivity, result repeatability, response time, operational lifetime, and storage lifetime. | 1 |
| Lec 3-4 | The classic classification of sensors based on the type of transducer. | 2 |
| Lec 5 | Classification of biosensors based on the type of receptor (e.g., enzymes, antibodies, DNA) influencing the bioselectivity of the sensor, as well as the type of transducer affecting the sensitivity of the biosensor. | 1 |
| Lec 6-7 | Fundamentals of analytical optical methods used in sensing: absorption of radiation, fluorescence, chemiluminescence, bioluminescence. Surface Plasmon Resonance (SPR). Piezoelectric phenomenon. Application of piezoelectric crystal as a mass sensor (quartz crystal microbalance). Sensors utilizing acoustic waves in piezoelectric crystals. | 2 |
| Lec 8 | Biological materials used in the construction of biosensors: enzymes, tissues, cellular organelles (mitochondria, chloroplasts), microorganisms (bacteria, yeast, single-cell algae), higher organisms and their organs (e.g., insects), antibodies, nucleic acids (DNA), other biologically active compounds (e.g., hemoglobin). Indicator organisms as biosensors. | 1 |
| Lec 9 | Methods of immobilizing biological material in biosensors: adsorption, cross-linking, entrapment in polymeric gels, covalent binding, microencapsulation. | 1 |
| Lec 10 | Applications of sensors and biosensors in medicine, production control, analysis of food (including genetically modified food), control of biotechnological processes, environmental protection, defense, and scientific research. | 1 |

| | | |
|---|---|---|
| Lec 11-12 | Chip-based laboratory - LOC - Lab-on-a-chip, the concept of operation of an analytical microchip, application of LOC in chemical and biochemical analysis (medical diagnostics), use of devices in the food, cosmetic industry, and environmental protection. | 2 |
| Lec 13-14 | Biomimetic sensor devices: artificial nose, artificial tongue, odor reproduction. | 2 |
| Lec 15 | Prospects for the development of sensor devices: further miniaturization of devices and associated challenges, multifunctional devices, personalized diagnostics (POC, point-of-care). | 1 |
| | Total hours | 15 |

| **~~Classes~~** | | **~~Number of hours~~** |
|---|---|---|
| Cl 1 | | |
| Cl 2 | | |
| Cl 3 | | |
| Cl 4 | | |
| .. | | |
| | ~~Total hours~~ | |

| **Laboratory** | | **Number of hours** |
|---|---|---|
| Lab 1 | Organizational activities - Occupational Health and Safety regulations, discussion of the course program, and conditions for course completion. Overview of basic electroanalytical techniques applied in sensing and biosensing (voltammetric techniques, including cyclic voltammetry - CV, pulse voltammetry - differential pulse voltammetry - DPV, chronoamperometry - CA; polarographic techniques; potentiometric techniques). | 2 |
| Lab 2 | Potentiometry - direct potentiometric methods (standard addition method), application of ion-selective electrodes for determining the content of, among others, chloride, magnesium, potassium, and hydrogen ions in food products. Selectivity of ion-selective electrodes, limits of detection. | 4 |
| Lab 3 | Voltammetric methods - characteristics of the working electrode (platinum, carbon, glass, and gold electrodes). Selection of the reference electrode. Preparation of electrodes for work, storage, cleaning, measurements, and selection depending on the depolarizer used. | 4 |
| Lab 4 | Constant current voltammetry techniques in sensing - determination of N-acetyl-4-aminophenol (paracetamol) using cyclic voltammetry (CV) and differential pulse voltammetry (DPV). | 4 |
| Lab 5 | Semiconductor structures in sensing - electrode modification. Electropolymerization of conjugated systems (e.g., aniline and its derivatives) using voltammetric and chronoamperometric methods. Characteristics of the obtained polymer film. | 4 |
| Lab 6 | Biosensors. Investigation of the activity of enzymatic proteins used in biosensing using spectrophotometric methods. Determination of optimal working conditions for enzymes as native and immobilized proteins. | 4 |
| Lab 7 | Biosensor for determining glucose levels. Characterization of the operation of enzymatic biosensors based on a glucometer - introduction to techniques of enzyme immobilization on the electrode surface, determination of glucose concentration in solutions and biological samples. Determination of detection limits, sensor selectivity (interferences). | 4 |
| Lab 8 | Semiconductor nanostructures in sensing and biosensing - synthesis and surface modification of nanomaterials to prepare a matrix for constructing biosensors. | 4 |

| | | |
|---|---|---|
| | Total hours | **30** |
| **~~Project~~** | | **~~Number of hours~~** |
| Proj 1 | | |
| Proj 2 | | |
| Proj 3 | | |
| Proj 4 | | |
| … | | |
| | ~~Total hours~~ | |
| **~~Seminar~~** | | **~~Number of hours~~** |
| ~~Semin 1~~ | | |
| ~~Semin 2~~ | | |
| ~~Semin 3~~ | | |
| ~~…~~ | | |
| | ~~Total hours~~ | |

| **TEACHING TOOLS USED** |
|---|
| N1. Lecture with audiovisual aids.<br>N2. Laboratory classes - conducting experiments.<br>N3. Laboratory classes - preparation of a report. |

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P (lecture) | PEU_W01- PEU_W04 | passing with a grade |
| F1 (laboratory) | PEU_U01 - PEU_U04 | passing with a grade |
| F2 (laboratory) | PEU_U01 - PEU_U04, PEU_K01_K02 | Assessment of the correctness of experiment execution and preparation of a report after completing laboratory classes |
| P (laboratory) = = 0,6 x F1 + 0,4 x F2; | | |

| **PRIMARY AND SECONDARY LITERATURE** |
|---|

**PRIMARY LITERATURE:**

[1] Florinel-Gabriel Bănică, *Chemical Sensors and Biosensors: Fundamentals and Applications*, John Wiley and Sons, Chichester, 2012

**SECONDARY LITERATURE:**

[2] R. F. Taylor, J. S. Schultz (red.), *Handbook of chemical and biological sensors*, IOP, Philadelphia, Bristol, 2003

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

Joanna Cabaj, joanna.cabaj@pwr.edu.pl

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

**SUBJECT CARD**

**Name of subject in Polish** Ochrona środowiska w technologii chemicznej
**Name of subject in English** Environmental protection in chemical industry
**Main field of study (if applicable):** Chemical Engineering and Technology
**Specialization (if applicable):** Advanced Chemical Technology
**Profile: academic**
**Level and form of studies:** 2nd level, full-time
**Kind of subject:** obligatory
**Subject code W03CET-SM2015W, W03CET-SM2015L**
**Group of courses** NO

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 15 | | 30 | | |
| Number of hours of total student workload (CNPS) | | | | | |
| Form of crediting (Examination / crediting with grade) | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | 1 | | 2 | | |
| including number of ECTS points for practical classes (P) | | | 2 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0,6 | | 1,2 | | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Basic environmental knowledge
2. Basics of chemical production
3. Knowledge of the basics of general chemistry

**SUBJECT OBJECTIVES**

C1 Familiarization students with the basic terminology used in environmental protection and shaping, sozology, environmental law.
C2 Familiarization students with the principles of environmental protection, systems of environmental management, principles of sustainable development, management of natural resources, including energy resources, and use of renewable resources.
C3 Familiarization students with the mechanisms and effects of human activities with particular emphasis on the impact of chemical industry activities on the natural environment.

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:

PEU_W01 Knows the basics of chemical production, basic terminology in the field of environmental protection and basic legal regulations in the field of environmental protection.

PEU_W02 Knows the industry-environment relationship and is able to determine the state of impact of the chemical industry on the environment. Knows the basics of conducting measurements in chemical production and for environmental monitoring purposes in legally regulated areas.

PEU_W03 Knows the structure of the chemical industry in Poland, the role of innovation and special economic zones; knows the basic problems and challenges of the chemical industry and environmental management systems.

PEU_W04 Knows energy raw materials, knows what are the prospective trends in the use of natural resources, renewable raw materials, as well as biomass in the chemical and energy industries. Knows what energy security is, knows the energy goals of the European Union and the principles of rational energy management in the chemical industry.

PEU_W05 Knows the types and uses of water in the chemical industry. Knows basic solutions in water and sewage management of chemical plants.

PEU_W06 Knows what impact the chemical industry has on air, water, and soil pollution. Knows methods of preventing air, water, and soil pollution as well as legal regulations in this area. Knows what remediation is and knows remediation techniques.

PEU_W07 Knows what are the sources of waste in the chemical industry. Knows waste classification and legal regulations in this area. Knows the methods of waste neutralization and utilization as well as the principles of green chemistry in waste disposal

relating to skills:

PEU_U01 Is able to determine the threats resulting from the use of chromium compounds in the tanning industry and characterize the methods of removing these compounds from industrial wastewater.

PEU_U02 Is able to characterize biosorption and bioaccumulation processes and determine the kinetics of the biosorption process.

PEU_U03 Is able to select the appropriate type of ionite for the removal of metal ions from post-plating wastewater and determine its ion-exchange capacity.

PEU_U04 Is able to carry out the desulfurization process of liquid products in laboratory conditions and compare the effectiveness of the applied methods.

PEU_U05 Is able to carry out the desulfurization process of gaseous products using absorption and adsorption methods.

PEU_U06 Is able to analyze the FT-IR spectrum.

PEU_U07 Has the ability to work individually and in a team.

PEU_U08 Has the ability to use acquired knowledge to creatively analyze and solve problems.

relating to social competences:

PEU_K01 Is aware of the threats to the environment associated with the functioning of the chemical industry.

PEU_K02 Is aware of the need for continuous search for new forms and methods of environmental protection and rational management of environmental resources.

PEU_K03 Is able to work in a team to solve a problem.

PEU_K04 Is aware of responsibility for own work, is open to exchange of ideas and new challenges.

| PROGRAMME CONTENT | | |
|---|---|---|
| **Lecture** | | **Number of hours** |
| Lec 1 | **Basics of chemical production:** chemical industry products; basic definitions related to environmental protection and management; environmental protection activities; natural resources and their rational use, renewable resources; basic environmental protection instruments, elements of environmental protection policy, methods of assessing the state of the environment. | 2 |
| Lec 2 | **Industry-environment relationship, measurements:** impact of the chemical industry on the environment; effects of pro-environmental activities of the chemical industry; the role of industrial analytics; rules for conducting measurements in the chemical industry and environmental monitoring in legally regulated areas. Ecological disasters related to the functioning of the chemical industry. | 2 |
| Lec 3 | **Structure of the chemical industry in Poland, environmental management systems:** production structure and employment in the chemical industry; role of foreign direct investments and special economic zones; environmental management systems; BAT; the role of research and innovation in the development of environmentally friendly industry. | 2 |
| Lec 4 | **Energy management:** history and future of energy changes; electricity production in Poland and in the world; raw material base; renewable energy sources; energy problems and energy policy goals; electricity in the chemical industry; energy security and energy efficiency, rational energy management in the chemical industry. | 2 |
| Lec 5 | **Water environment protection:** water supply, water used in the chemical industry - types, use, consumption and quality requirements; water treatment methods, filter selection; water pollution and protection; wastewater in the chemical industry; water and sewage management; legal regulations. | 2 |
| Lec 6 | **Soil and atmosphere protection:** the impact of the chemical industry on atmosphere and soil pollution; characteristics of gaseous pollutants; methods of preventing atmospheric pollution; remediation. | 2 |
| Lec 7 | **Waste management in the chemical industry:** definition of waste, types and legal classification of waste, sources of waste in the chemical industry; methods of waste utilization and neutralization; the problem of hazardous waste; waste-free methods; principles of "green chemistry" in waste disposal. | 2 |
| Lec 8 | **Summary of the lecture and crediting with grade.** | 1 |
| | Total hours | **15** |
| **Laboratory** | | **Number of hours** |
| Lab 1 | Introduction. OSH training. | 2 |
| Lab 2 | Removal of chromium ions from wastewater from the tanning industry. Part I - Reduction of Cr (VI) to Cr (III) using oxalic acid. | 4 |
| Lab 3 | Removal of chromium ions from wastewater - Part II - Removal of Cr (III) from wastewater by biosorption. | 4 |
| Lab 4 | Recovery of heavy metals from post-plating wastewater. | 4 |
| Lab 5 | Desulphurization processes of gas raw materials. | 4 |

| | | |
|---|---|---|
| Lab 6 | Desulfurization processes of liquid raw materials | 4 |
| Lab 7 | Determination of impurities in liquid and solid samples using the FTIR method. | 4 |
| Lab 8 | Extra laboratory classes. | 4 |
| | Total hours | **30** |

| **TEACHING TOOLS USED** |
|---|
| N1. Lecture with multimedia presentation.<br>N2. Debate and conversation.<br>N3. Audiovisual communication.<br>N4. Job at laboratory. Performing experiments.<br>N5. Preparation of the report. |

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| **P (lecture)** | PEU_W01-PEU_W07<br>PEU_U08<br>PEU_K01-PEU_K04 | Final test<br>3,0 if 50% – 59%<br>3,5 if 60 – 69 %<br>4,0 if 70 – 79 %<br>4,5 if 80 – 89%<br>5,0 if 90 – 100 % |
| F1-F7 (laboratory) | PEU_U01- PEU_U08<br>PEU_K03-PEU_K04 | Grade of the short tests and reports |
| **P (laboratory)** =(F1+F2+F3+F4+F5+F6+F7)/7 | | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] Porteous A. Dictionary of Environmental Science and Technology, New York, 2008, Wiley
[2] S. E. Manahan, Environmental science and technology, CRC Taylor & Francis, Boca Raton, London, New York, 2007
[3] G.Manahan; Environmental science technology and chemistry, CRC Press 2000
[4] Polish and European legal regulations regarding environmental protection
[5] Waste tire pyrolysis and desulfurization of tire pyrolytic oil (TPO) – A review, M. Mello, H. Rutto, T. Soedigeng, Journal of the Air & Waste Management Association, Volume 73, 2023 - Issue 3
[6] Summary of research progress on industrial flue gas desulfurization technology, X. Li et al. Separation and Purification Technology, Volume 281, 2022.
[7] Removal of Hydrogen Sulfide From Various Industrial Gases: A Review of The Most Promising Adsorbing Materials, A.G. Georgiadis et al. Catalysts 2020, 10(5), 521


**SECONDARY LITERATURE:**


[1] Comprehensive Renewable Energy, 2nd edition The Impact on the Environment in the Production of Photovoltaic Systems: With a Focus on Metal Recovery Ewa Klugmann-Radziemska, Elsevier 2020
[2] G. W. vanLoon, S.J. Duffy, Environmental chemistry. A global perspective, Oxford University Press, 2005
[3] Scientific and technical journals

| SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS) | |
|---|---|
| **Lecture** | **Małgorzata Mironiuk**<br>malgorzata.mironiuk@pwr.edu.pl |
| **Laboratory** | **Rafał Łużny**<br>rafal.luzny@pwr.edu.pl |

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY OF CHEMISTRY

**SUBJECT CARD**

**Name of subject in Polish:** **Zielona chemia i zrównoważone technologie**
**Name of subject in English:** **Green Chemistry and Sustainable Technology**
**Main field of study (if applicable):** Chemical Engineering and Technology
**Specialization (if applicable):** Advanced Chemical Technology
**Profile**: academic
**Level and form of studies:** 2nd level, full-time
**Kind of subject:** obligatory
**Subject code:** W03CET-SM2010W, W03CET-SM2010P
**Group of courses:** NO

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 15 | | | 30 | |
| Number of hours of total student workload (CNPS) | 25 | | | 75 | |
| Form of crediting (Examination / crediting with grade) | exam | | | crediting with grade | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | 2 | | | 3 | |
| including number of ECTS points for practical classes (P) | | | | 3 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0,6 | | | 1,2 | |

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1.

**SUBJECT OBJECTIVES**

C1 students' understanding of advanced issues in the field of green chemistry and chemical technologies in relation to sustainable development goals
C2 deepening students' skills in group work and strengthening their need for constant improvement

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
a student completing a course
PEU_W01 has in-depth knowledge of the principles of green chemistry

PEU_W02 has advanced knowledge of the sustainable development of the chemical industry, as well as techniques, processes and technologies supporting the achievement of sustainable development goals

relating to skills:
a student completing a course
PEU_U01 is able to work using a case study
PEU_U02 is able to plan activities, work in a group, collect and analyze data, develop a project in the form of a compact document,
PEU_U03 is able to organize a discussion, present the results of one's work, and defend the presented theses

relating to social competences:
a student completing a course
PEU_K01 is aware of the importance of knowledge in a context beyond technical and engineering aspects
PEU_K02 is ready to use the experience and knowledge of specialists
PEU_K03 is aware of the role of an engineer in the modern world, including the need to inform society about the most important aspects of sustainable development

**PROGRAMME CONTENT**

| **Lecture** | | **Number of hours** |
|---|---|---|
| Lec 1 | Green Chemistry – principles, concepts | 2 |
| Lec 2 | Green Chemistry – green catalysis, green solvents, green processing | 2 |
| Lec 3 | Green Chemistry – safety, waste management | 2 |
| Lec 4 | Introduction to sustainable development (SD) – concepts, principles, definitions, models | 2 |
| Lec 5 | A role of sustainability in biotechnology and chemical industry – the pollution prevention in chemical industry, the design and modeling of the sustainable manufacturing and industrial processes, conservation and management of resources | 2 |
| Lec 6 | Sustainable development in chemistry and chemical technology – case studies | 2 |
| Lec 7 | Environmental sustainability, Zero emission concept, Cleaner Production concept | 2 |
| Lec 8 | The challenges for green chemistry and sustainable chemical technologies | 1 |
| | **Total hours** | **15** |

| **Project** | | **Number of hours** |
|---|---|---|
| Pr1 | Learning with the project method – introduction. Selection and discussion of group and individual project topics. | 2 |
| Pr2-Pr7 | Working on a project. Collecting data, discussing assumptions for team and individual projects. Consultations. Brainstorm. | 12 |
| Pr8 | Presentations of assumptions for team and individual projects – discussion. | 2 |
| Pr9-Pr14 | Working on a project. Development of team and individual projects. Preparation of final reports | 12 |
| Pr5 | Presentations of team and individual projects – summary discussion. | 2 |

| | | |
|---|---|---|
| | Total hours | **30** |

| **TEACHING TOOLS USED** |
|---|
| N1. Multimedia presentation<br>N2. Discussion<br>N3. Consultations |

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P=0,1xF1+0,9xF2 | PEU_W01-PEU_W02<br>PEU_K01, PEU_K03 | F1-Engagement rating in discussions (10%); F2-Exam (90%) |
| P=0,4xF1+0,3xF2+0,3xF3 | PEU_U01-PEU_U03<br>PEU_K01-PEU_K03 | Assessment of: F1-quality of presentation, involvement in group work, participation in discussions (40%); F2-Group project evaluation (30%); F3-Assessment of the individual project (30%) |

| **PRIMARY AND SECONDARY LITERATURE** |
|---|
| **PRIMARY LITERATURE:**<br>[1] Vincenzo Piemonte, Marcello De Falco, Angelo Basile, Sustainable Development in Chemical Engineering: Innovative Technologies, Wiley 2013, ISBN: 978-1-119-95352-4<br>[2] Sustainable Industrial Processes, ed. By F. Cavani, G. Centi, S. Perathoner and F. Trifiro, Wiley-VCH 2009<br>**SECONDARY LITERATURE:**<br>[1] Current scientific publications<br>[2] Current UN, EU, USEPA reports on the SDGs |

| **SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)** |
|---|
| Dr hab. inż. Piotr Rutkowski, prof. uczelni, piotr.ruktowski@pwr.edu.pl |

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

**SUBJECT CARD**

**Name of subject in Polish …Reaktory heterogeniczne…….**
**Name of subject in English ……Heterogeneous reactors…….**
**Main field of study (if applicable): …Chemical engineering and technology…….**
**Specialization (if applicable): …Advanced chemical engineering and green technology…..**
**Profile: academic**
**Level and form of studies: 2nd level**
**Kind of subject: obligatory**
**Subject code** W03CET-SM2003W, W03CET-SM2003P
**Group of courses NO**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | | 45 | |
| Number of hours of total student workload (CNPS) | 75 | | | 75 | |
| Form of crediting (Examination / crediting with grade) | Exam | | | Crediting with grade | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | 3 | | | 3 | |
| including number of ECTS points for practical classes (P) | | | | 3 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1,2 | | | 1,8 | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Knowledge of mathematics, physics, and mass transfer phenomena at the bachelor's level (chemical engineering or related)
2. Knowledge of the basics of chemical reactor engineering

**SUBJECT OBJECTIVES**

C1 To familiarize students with the topic and design of heterogeneous chemical reactors (non-catalytic reactions)
C2 To introduce students to the topic of heterogeneous catalysis
C3 To familiarize students with the design of heterogeneous catalytic reactors
C4 To introduce students to the topic and design of high-pressure reactors

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:

PEU_W01 – student knows the principles of designing chemical reactors for heterogeneous non-catalytic processes

PEU_W02 - student knows the principles of designing chemical reactors for heterogeneous catalytic processes

PEU_W03 - student knows the principles of design and operation of high-pressure reactors

relating to skills:

PEU_U01 – student is able to determine the limiting resistance of mass transfer in non-catalyzed heterogeneous processes and derive the process rate equation

PEU_U02– student is able to determine the limiting resistances to mass transfer in heterogeneous catalytic processes and derive the process rate equation

PEU_U03 – student can calculate the volume, reaction time or efficiency in heterogeneous reactors.

**PROGRAMME CONTENT**

| **Lecture** | | **Number of hours** |
|---|---|---|
| Lec 1 | Optimal temperature regime | 2 |
| Lec 2 | Ammonia production. Ammonia cracking to produce hydrogen | 2 |
| Lec 3 | Heterogeneous reactions | 1 |
| Lec 4 | Gas-liquid and liquid-liquid reaction systems | 3 |
| Lec 5 | Gas-solid non-catalytic systems | 3 |
| Lec 6 | Heterogeneous catalysis and catalytic kinetics | 3 |
| Lec 7 | Heterogeneous catalytic reactor design | 2 |
| Lec 8 | Catalyst deactivation and strategies for its testing | 2 |
| Lec 9 | External diffusion effects in heterogeneous catalytic reactions | 2 |
| Lec 10 | Diffusion and reaction in porous catalyst | 3 |
| Lec 11 | Slurry reactors | 1 |
| Lec 12 | Thermodynamics of high-pressure processes | 2 |
| Lec 13 | Supercritical water – green processes and chemical reactor selection. Supercritical water oxidation | 2 |
| Lec 14 | Hydrothermal gasification | 2 |
| | Total hours | 30 |

| **Project** | | **Number of hours** |
|---|---|---|
| Proj 1 | Multiple heterogeneous reactions – isothermal performance, process design | 2 |
| Proj 2 | Multiple heterogeneous reactions – non-isothermal performance, process design | 2 |
| Proj 3 | Packed bed reactor; pressure drop | 2 |
| Proj 4 | Optimal temperature regime for catalytic reactor – exothermic reactions | 5 |

| | | |
|---|---|---|
| Proj 5 | Ammonia synthesis | 3 |
| Proj 6 | Optimal temperature regime for catalytic reactor – endothermic reactions | 3 |
| Proj 7 | Hydrogen production by ammonia cracking | 2 |
| Proj 8 | Absorber design (chemisorption) | 5 |
| Proj 9 | Gas-solid non-catalyzed system design | 4 |
| Proj10 | Catalytic reactions – determination of the process rate and reactor design | 5 |
| Proj11 | Catalytic deactivation. Reactor design. | 2 |
| Proj12 | Catalytic reactor design – external diffusion effects | 2 |
| Proj13 | Catalytic reactor design – diffusion in porous catalyst | 2 |
| Proj14 | Catalytic membranę reactor design | 2 |
| Proj15 | Thermodynamics of high-pressure processes | 2 |
| Proj16 | Partial oxidation of p-xylene in supercritical water | 2 |
| | Total hours | **45** |

**TEACHING TOOLS USED**

N1. Multimedia presentation
N2. Polymath and Matlab software
N3. MS Office (Excel)

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| F (project) | PEU_U01 – U03 | Grading based on the work on projects |
| P (lecture) | PEU_W01 -W03 | Exam |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


[1] S. Fogler, Elements of Chemical Reaction Engineering, 6th Edition, Pearson, 2020.

[2] S. Fogler, Essentials of Chemical Reaction Engineering, 2nd Edition, Pearson, 2018.

[3] O. Levenspiel: Chemical Reaction Engineering, 3rd edition, John Wiley & Sons, New Jersey, 1999.

[4] R. Smith, H. Inomata, C. Peters, Introduction to Supercritical Fluids, A Spreadsheet-based approach, Elsevier, 2013.


**SECONDARY LITERATURE:**


[1] I. Zizovic, Chemical Reaction Engineering with MATLAB examples, Irena Zizovic, Script, Politechnika Wrocławska, 2019.


**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**


**Irena Žižović (irena.zizovic@pwr.edu.pl)**

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

**SUBJECT CARD**

**Name of subject in Polish Projektowanie instalacji przemysłowych**
**Name of subject in English Industrial plants design principles**
**Main field of study (if applicable): Chemical Engineering and Technology**
**Specialization (if applicable): Advanced Chemical Technologies**
**Profile: academic**
**Level and form of studies: 2nd level, full-time**
**Kind of subject: obligatory**
**Subject code W03CET-SM2014W, W03CET-SM2014P**
**Group of courses NO**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 15 | | | 30 | |
| Number of hours of total student workload (CNPS) | 30 | | | 60 | |
| Form of crediting (Examination / crediting with grade) | Crediting with grade | | | Crediting with grade | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | **1** | | | **2** | |
| including number of ECTS points for practical classes (P) | | | | 2 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.6 | | | 1,2 | |

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Knowledge of unit operations in chemical and process engineering.
2. Basics of process design.
3. Knowledge of process equipment.

**SUBJECT OBJECTIVES**

C1 Providing the students with industrial plant design tasks and feasibility analysis of the new plant, rules of the integrated project elaboration.
C2 Providing the students with basic knowledge of raw materials and energy supply systems, requirements concerning raw materials and products quality, optimization and intensification of integrated process.
C3 Providing the students with the rules of production process course elaboration, including the rules of elaboration of schematic diagram and a technological-apparatus scheme of the integrated process.
C4 Providing the students with the rules of process equipment selection, apparatus constructions, constructional materials, methods of selection of control-measuring apparatuses and regulation equipment of the plant under design.
C5 Presentation of investment costs estimation and calculation of production costs of the designed integrated process.
C6 Making project of the of an integrated process.

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
PEU_W01 – knows basics of unit operations design,
PEU_W02 – knows process intensification rules,
PEU_W03 – has thorough knowledge as far as concerning the apparatus and equipment used in industrial plants.

relating to skills:
PEU_U01 – can make design calculations of selected unit operations in integrated processes,
PEU_U02 – can integrate the processes,
PEU_U03 – can select the sequence of unit operations for technological process in the plant (integrated processes) designs.

relating to social competences:
PEU_K01 – can cooperate in design group,
PEU_K02 – can present the work results.

## PROGRAMME CONTENT

| | **Lecture** | **Number of hours** |
|---|---|---|
| Lec 1 | Integration of unit operations. Industrial plant. Industrial plant design principles. Feasibility analysis of the new plant. | 2 |
| Lec 2 | Process integration rules. Technological – economic assumptions. Elaboration rules of the process project of industrial plant. Optimization of process solutions. | 2 |
| Lec 3 | Examples of integrated processes application. Process data. Raw materials and the products, energy, waste. Parameters of unit operations. Integrated process course. | 2 |
| Lec 4 | Principles balancing rules. Process equipment, industrial plant, constructional materials. | 2 |
| Lec 5 | Control and regulation of designed integrated process – industrial plant. | 2 |
| Lec 6 | Technological – apparatus scheme of integrated processes. Spatial distribution of apparatus and equipment in industrial plant. | 2 |
| Lec 7 | Investment costs and calculation of project cost. | 2 |
| Lec 8 | Analysis of advantages resulting from process integration – examples of real process solutions. | 1 |
| | **Total hours** | **15** |

| | **Project** | **Number of hours** |
|---|---|---|
| Proj 1 | Feasibility analysis of a new (exemplary) investment. | 2 |
| Proj 2 | Elaboration of chemical and technological concept of the design task – an exemplary industrial plant. | 2 |
| Proj 3, Proj 4 | Selection of individual parameters of unit operations for specified design task – integrated proces – according to elaborated schematic diagram of the designed integrated process. | 4 |
| Proj 5 – Proj 7 | Calculation of material and energy balances, calculation of indicators of raw material and energy consumption in integrated process. Calculating of the product/products composition, waste composition and elaboration of their storage/utilization method. | 6 |
| Proj 8 – Proj 10 | Selection and/or design of process apparatuses, equipment selection, selection of constructional materials for integrated process. | 6 |
| Proj 11 | Elaboration of measurement, control and regulation system of integrated process. Selection of control and measurement equipment. Selection of automatic control systems. | 2 |
| Proj 12, Proj 13 | Elaboration of technological-apparatus scheme of the integrated process. Spatial distribution of apparatuses and equipment. | 4 |
| Proj 14, Proj 15 | Estimated investment costs and production costs. | 4 |
| | **Total hours** | **30** |

## TEACHING TOOLS USED

N1. Lecture with multimedia presentation.
N2. Integrated project of the given task – elements of individual and group work.
N3. Design consultations.

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P1 | PEU_W01 – PEU_W03 | Crediting with grade. |
| P2 | PEU_U01 – PEU_U03, PEU_K01-PEU_K02 | Crediting with grade. Project evaluation. |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] R. Koch, A. Kozioł: *Dyfuzyjno–cieplny rozdział substancji*, WNT Warszawa, 1994.
[2] R. Koch, A. Noworyta: *Procesy mechaniczne w inżynierii chemicznej*, WNT Warszawa, 1995.
[3] A. Burghardt, G. Bartelmus: *Inżynieria reaktorów chemicznych*, PWN Warszawa, 2001.
[4] S. Kucharski, J. Głowiński: *Podstawy obliczeń projektowych w inżynierii chemicznej*, OWPWr, Wrocław, 2000.
[5] D.W. Green, R.H. Perry (red.): *Perry's chemical engineers' handbook*, 8th ed., McGraw–Hill, 2007


**SECONDARY LITERATURE:**


[1] W.D. Seider: *Process design principles*, J.W.&S., 1999.
[2] U. Bröckel, W. Meier, G. Wagner (red.): *Product design and engineering.* Vol.1*: Basics and technologies,* Vol. 2: *Raw materials, additives and application*, Wiley, 2007.


## SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)


**Dr inż. Anna Stanclik (anna.stanclik@pwr.edu.pl)**
**Dr inż. Nina Hutnik (nina.hutnik@pwr.edu.pl)**

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of CHEMISTRY

**SUBJECT CARD**

**Name of subject in Polish** Procesy membranowe
**Name of subject in English** Membrane processes
**Main field of study (if applicable):** Chemical Engineering and Technology
**Specialization (if applicable):** Advanced Chemical Engineering
**Profile:** academic
**Level and form of studies:** 2nd level
**Kind of subject:** obligatory
**Subject code** W03CET-SM2002W, W03CET-SM2002L, W03CET-SM2002S
**Group of courses** NO

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 15 | | 45 | | 15 |
| Number of hours of total student workload (CNPS) | 50 | | 75 | | 25 |
| Form of crediting (Examination / crediting with grade) | crediting with grade | | crediting with grade | | crediting with grade |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | 2 | | 3 | | 1 |
| including number of ECTS points for practical classes (P) | | | 3 | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0,6 | | 1,8 | | 0,6 |

**1w+3l +1s (2+3+1 ECTS).**

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1.Fundamentals of organic chemistry
2 Fundamentals of chemical engineering

**SUBJECT OBJECTIVES**

C1 To become familiar with the construction and characteristics of membranes.
C2 To become familiar with the types of membrane processes and their application.
C3 To become familiar with measurement methods during a membrane process.

**SUBJECT EDUCATIONAL EFFECTS**

In terms of knowledge:
PEU_W01 The student knows the chemical and physical structure of membranes.
PEU_W02 The student knows what membrane processes are and when to use them.

From the scope of skills:
PEU_U01 The student is able to carry out a process on a membrane plant and determine its membrane performance and selectivity.

PEU_U02 The student knows how to prepare documentation for a membrane process.
PEU_U03 The student is able to find examples of applications of membrane processes in the literature and prepare a presentation on them.

In terms of social competence:
PEU_K01 The student is able to engage in discussion and critically evaluate his/her own work and that of others in the course.

**PROGRAMME CONTENT**

| | **Lecture** | **Number of hours** |
|---|---|---|
| Lec 1 | Introduction to clean technologies. | 2 |
| Lec 2 | Circular economy. Application of membrane processes in waste fractionation. | 2 |
| Lec 3 | Membrane construction and structure of membrane modules. | 2 |
| Lec 4 | Pressurised membrane processes. | 3 |
| Lec 5 | Diffusion membrane processes. | 3 |
| Lec 6 | Membrane electro-processes. Liquid membranes. | 2 |
| Lec 7 | Written course credit | 1 |
| | Total hours | **15** |

| | **Laboratory** | **Number of hours** |
|---|---|---|
| La1 | Microfiltration of bacterial and yeast cells. | 5 |
| La2 | Ultrafiltration process. | 5 |
| La3 | Protein hydrolysis coupled to nanofiltration. | 15 |
| La4 | Pervaporation of beer. | 5 |
| La5 | Dialysis. | 5 |
| La6 | Membrane extraction. | 5 |
| La7 | Reverse osmosis | 5 |
| | Total hours | **45** |

| | **Seminar** | **Number of hours** |
|---|---|---|
| Se1 | Introduction to the class - application of membrane processes. | 1 |

| | | |
|---|---|---|
| Se2 | Micro- and ultrafiltration processes. | 2 |
| Se3 | Nanofiltration and reverse osmosis. | 2 |
| Se4 | Membrane extraction and distillation. | 2 |
| Se5 | Pervaporation and dialysis. | 2 |
| Se6 | Vapour and gas separation. | 2 |
| Se7 | Liquid membranes. Membrane fabrication. | 2 |
| Se8 | Electrodialysis, electrodiffusion. | 2 |
| | Total hours | **15** |

| **TEACHING TOOLS USED** |
|---|
| N1. Lecture with multimedia presentation<br>N2. Laboratory.<br>N3. Students presentations.<br>N4. Consultations. |

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P (lecture) | PEU_W01<br>PEU_W02<br>PEU_W03<br>PEU_W04 | Credit test |
| F1 (laboratory)<br><br>P=F1 | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01<br>PEU_K02 | Laboratory exercise reports (arithmetic mean) |
| P (seminar) | PEU_U04 | presentation |
| 3.0 if $3.00 \leq P < 3.25$<br>3.5 if $3.25 \leq P < 3.75$<br>4.0 if $3.75 \leq P < 4.25$<br>4.5 if $4.25 \leq P < 4.75$<br>5.0 if $4.75 \leq P$ | | |

| **PRIMARY AND SECONDARY LITERATURE** |
|---|

**PRIMARY LITERATURE:**

**LITERATURA PODSTAWOWA:**


[1] Membrane processes, Robert Rautenbach, 1989.

[2] Membrane Modification: Technology and Applications – Nidal Hilal, Mohammed Khayet, Chris Wright, 2012.

[3]


**SECONDARY LITERATURE:**


[4] Multimedia presentation materials.


**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**


**Anna Trusek,** anna.trusek@pwr.edu.pl

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of CHEMISTRY

**SUBJECT CARD**

**Name of subject in Polish** Nanotechnologia
**Name of subject in English** Nanotechnology
**Main field of study (if applicable):** Chemical Engineering and Technology
**Specialization (if applicable):** Advanced Chemical Engineering
**Profile:** academic
**Level and form of studies:** 2nd level
**Kind of subject:** obligatory
**Subject code** W03CET-SM2009W, W03CET-SM2009L
**Group of courses** NO

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 15 | | 30 | | |
| Number of hours of total student workload (CNPS) | 25 | | 50 | | |
| Form of crediting (Examination / crediting with grade) | crediting with grade | | crediting with grade | | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | **1** | | 2 | | |
| including number of ECTS points for practical classes (P) | | | 2 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.6 | | 1.2 | | |

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1.Fundamentals of physical chemistry
2 Fundamentals of biotechnology
3 Fundamentals of materials engineering

**SUBJECT OBJECTIVES**

C1 To become familiar with the concepts of nanotechnology.
C2 To become familiar with methods of obtaining and characterising nanomaterials.
C3 To become familiar with the possible applications of nanoengineering and nanomaterials in various fields.

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
PEU_W01 Knows the concepts of nanotechnology
PEU_W02 Has knowledge of methods of obtaining nanomaterials
PEU_W03 Has knowledge of characterisation techniques for nanomaterials
PEU_W04 Knows the applications of nanotechnology and nanomaterials in various fields

relating to skills:
PEU_U01 Can select a method and synthesise a chosen nanomaterial
PEU_U02 Can carry out investigations of nanomaterial properties and their characterisation using specialised equipment
PEU_U03 Can analyse and process the obtained test results

relating to social competences:
PEU_K01 Is able to cooperate in a laboratory group
PEU_K02 Feels responsible for the results of the assigned task

**PROGRAMME CONTENT**

| | **Lecture** | **Number of hours** |
|---|---|---|
| Lec 1 | Organising lesson. Credit requirements. Introduction -History of the development of nanotechnology and its applications in various fields. Properties of nanomaterials and how they differ from macroscale materials. New trends in nanotechnology. | 2 |
| Lec 2 | Nanoemulsions - manufacturing methods, characterisation and stability testing and applications. | 2 |
| Lec 3 | Metallic nanoparticles with the example of bionanosilver - preparation, properties and practical applications. | 2 |
| Lec 4 | Synthesis of metal oxide-based nanomaterials and their potential applications | 2 |
| Lec 5 | Definition of drug carriers. Mechanisms of release. | 2 |
| Lec 6 | Externally applied drug carriers - construction, use. | 2 |
| Lec 7 | Carriers in targeted therapy - construction, application. | 2 |
| Lec 8 | Written course credit. | 1 |
| | Total hours | **15** |

| | **Laboratory** | **Number of hours** |
|---|---|---|
| Lab 1 | Preparation, characterisation and stability testing of nanoemulsions. | 5 |
| Lab 2 | Bioinspired synthesis and characterisation of silver nanoparticles. | 5 |
| Lab 3 | Green synthesis of zinc oxide nanocrystals and their characterisation. | 5 |
| Lab 4 | Preparation of encapsulator drug carriers. | 5 |
| Lab 5 | Preparation of core-shell drug carriers. | 5 |
| Lab 6 | Printing of carriers on a bio-printer. Control of drug release. | 5 |
| | **Total hours** | **15** |

**TEACHING TOOLS USED**

N1. Lecture with multimedia presentation
N2. Laboratory instructions
N3. Laboratory workstations

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P (lecture) | PEU_W01<br>PEU_W02<br>PEU_W03<br>PEU_W04 | Credit test |
| F1 (laboratory)<br><br>P=F1 | PEU_U01<br>PEU_U02<br>PEU_U03<br>PEU_K01<br>PEU_K02 | Laboratory exercise reports (arithmetic mean) |
| 3.0 jeżeli 3.00 ≤ P < 3.25<br>3.5 jeżeli 3.25 ≤ P < 3.75<br>4.0 jeżeli 3.75 ≤ P < 4.25<br>4.5 jeżeli 4.25 ≤ P < 4.75<br>5.0 jeżeli 4.75 ≤ P | | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] S.M. Jafari, D.J. McClements „Nanoemulsions: Formulation, Applications, and Characterization", Academic Press, 2018

[2] V.A. Basiuk, E.V. Basiuk "Green Processes for Nanotechnology: From Inorganic to Bioinspired Nanomaterials", Springer, 2015

[3] M. Rai, C. Posten "Green biosynthesis of nanoparticles: mechanisms and applications", CBA International, 2013

[4] A.D.Sezer "Application of Nanotechnology in Drug Delivery" https://www.intechopen.com/books/application-of-nanotechnology-in-drug-delivery

[5] J.L.Arias "Nanotechnology and Drug Delivery" https://www.taylorfrancis.com/books/e/9780429073533


**SECONDARY LITERATURE:**


[1] M. Naito, T. Yokoyoma, K. Hosokawa, K. Nogi "Nanoparticle technology handbook", Elsevier B.V., 2018

[2] H. Sarma, S.J. Joshi, R. Prasad, J. Jampilek „Biobased Nanotechnology for Green Applications", Springer, 2022

[3] Inamuddin, A.M. Asiri "Applications of nanotechnology for green synthesis", Springer, 2020

[4] D.L. Feldheim, C.A. Foss "Metal nanoparticles: synthesis, characterization, and applications", Marcel Dekker, Inc., 2002


## SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)


**Anna Trusek,** anna.trusek@pwr.edu.pl

**Izabela Polowczyk,** izabela.polowczyk@pwr.edu.pl

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

**SUBJECT CARD**

**Name of subject in Polish … Numeryczne zastosowania w nano-inżynierii**
**Name of subject in English ……** Numerical applications in nano-engineering
**Main field of study (if applicable): …Chemical engineering and technology…….**
**Specialization (if applicable): …Advanced chemical engineering and green technology…..**
**Profile: academic**
**Level and form of studies: 2nd level**
**Kind of subject: obligatory**
**Subject code** W03CET-SM2008W, W03CET-SM2008P
**Group of courses NO**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 15 | | 30 | | |
| Number of hours of total student workload (CNPS) | 25 | | 50 | | |
| Form of crediting (Examination / crediting with grade) | Exam | | Crediting with grade | | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | 1 | | 2 | | |
| including number of ECTS points for practical classes (P) | | | 2 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 0.6 | | 1,2 | | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Knowledge of mathematics, physics, and mass transfer phenomena at the bachelor's level (chemical engineering or related)
2. Understanding of numerical algorithms
3. Basic understanding of chemical thermodynamics

**SUBJECT OBJECTIVES**

C1 To familiarize students with the current state of nano-type research
C2 To understand future applications in nano-materials
C3 To familiarize students with specific properties in the nano-scale
C4 To introduce students to the modeling methodology of nano-porous materials

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:

PEU_W01 – student understands the notion of nano-engineering and its role in future technologies
PEU_W02 - student knows the current trends of nano-technology developments
PEU_W03 - student knows how to model numerically the properties of nano-objects

relating to skills:
PEU_U01 – student is able to find and understand the literature related to nanotechnology
PEU_U02– student is able to discuss the current trends in nanotechnology
PEU_U03 – student can design a numerical modeling analyze of nano-materials

**PROGRAMME CONTENT**

| **Lecture** | | **Number of hours** |
|---|---|---|
| Lec 1 | Characteristics of the nano-scale properties. | 2 |
| Lec 2 | Numerical projects: basic notions and definitions | 2 |
| Lec 3 | Numerical projects in nano-materials. | 2 |
| Lec 4 | Surface and deformations in nanoscale. Nanoporous materials. | 2 |
| Lec 5 | Industrial applications of nanoporous materials | 2 |
| Lec 6 | Characteristics of nanoporous materials: adsorption | 2 |
| Lec 7 | Microscopic models of nanoporous materials and adsorption | 2 |
| Lec 8 | Interpretation of simulations of adsorption and diffusion in nanoprorous materials | 1 |
| | Total hours | 15 |

| **Project** | | **Number of hours** |
|---|---|---|
| Proj 1 | Definitions of models for simulations, basic Linux notions | 4 |
| Proj 2 | Setting-up and optimalization of the input data | 6 |
| Proj 3 | Examples of the Monte Carlo simulation methods | 4 |
| Proj 4 | Simulation of adsorption in porous systems | 6 |
| Proj 5 | Analysis of the simulation results: the role of adsorption energy | 4 |
| Proj 6 | Transport in nanaopores | 6 |
| Proj 7 | Adsorption in nanoporous systems | 3 |
| | Total hours | **30** |

**TEACHING TOOLS USED**

N1. Multimedia presentation
N2. Discussions and exercises
N3. Consultations

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming during semester), P – | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|

| | | |
|---|---|---|
| concluding (at semester end) | | |
| F (project) | PEU_U01 – U03 | Grading based on the work on projects |
| P (lecture) | PEU_W01 -W03 | Exam |

**PRIMARY AND SECONDARY LITERATURE**

**LITERATURA PODSTAWOWA:**

[1] Akhlesh Lakhtakia, Nanometer structures: Theory, modeling and simulation, SPIE Press 2004

**LITERATURA UZUPEŁNIAJĄCA:**

Internet.

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

**Bogdan Kuchta (bogdan.kuchta@pwr.edu.pl)**

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY OF CHEMISTRY

**SUBJECT CARD**

**Name of subject in Polish** Planowanie eksperymentów w Statistica
**Name of subject in English** Planning experiments in Statistica
**Main field of study (if applicable):** Chemical Engineering and Technology
**Specialization (if applicable): ……..**
**Profile: academic**
**Level and form of studies: 2nd level, full-time**
**Kind of subject: optional**
**Subject code W03CET-SM2101C**
**Group of courses NO**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | | 30 | | | |
| Number of hours of total student workload (CNPS) | | 50 | | | |
| Form of crediting (Examination / crediting with grade) | | crediting with grade | | | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | | 2 | | | |
| including number of ECTS points for practical classes (P) | | 2 | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | 1,2 | | | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Basics of probability theory: the concept of probability and its properties, independence of random events
2. Basic knowledge of mathematical analysis and linear algebra

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**SUBJECT OBJECTIVES**

C1 Getting to know the Statistica environment
C2 Learning about selected experiment planning techniques.
C3 Acquiring the ability to select an appropriate statistical test to analyze the results
C4 Acquiring the ability to use linear and non-linear regression in the analysis of results
C5 Acquiring the ability to use the selected Statistica package in planning the experiment and analyzing the results

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
Person who passed the subject:
PEU_W01 – Has knowledge in the field of statistics
PEU_W02 – Has knowledge in planning research using experimental methods used in biotechnology
relating to skills:
Person who passed the subject:
PEU_U01 – Can operate Statistica software
PEU_U02 – Is able to create an experiment diagram with a work schedule
PEU_U03 – Is able to perform basic statistical analyzes and correctly interprets the obtained results
relating to social competences:
Person who passed the subject:
PEU_K01 – Is ready to critically evaluate their knowledge
PEU_K02 – Is aware of the importance of acquired theoretical and practical knowledge and is ready to apply general and engineering skills in practice
PEU_K03 – Has the ability to work in a team of several people

**PROGRAMME CONTENT**

| | **Classes** | **Number of hours** |
|---|---|---|
| C1 | Introduction to Statistica.<br>Sample, types of data, data presentation | 2 |
| C2 | Variable distributions (normal, normality test, binomial distribution, Poisson) | 2 |
| C3 | Correlations, Anova | 2 |
| C4 | Sets of variables, group analysis | 2 |
| C5 | Data management. Worksheet formulas and multivariable transformation. Importing from Excel. Data preparation (cleaning and flirting) | 2 |
| C6 | Characteristics of the purpose and object of research | 2 |
| C7 | Optimal research plans. Selection based on the specific purpose and object of research | 2 |
| C8 | Complete plans. | 2 |
| C9 | Two-value complete or fractional plans. Bivalent elimination plans | 2 |
| C10 | Plans with three-valued input quantities. Plans in which some factors are bivalent and some are trivalent | 2 |
| C11 | Compositional master plans | 2 |
| C12 | Statistical analysis of results 1 | 2 |
| C13 | Statistical analysis of results 2 | 2 |
| C14 | Practical use of results | 2 |
| C15 | Collquium | 2 |
| | Total hours | **30** |

**TEACHING TOOLS USED**

N1. Multimedia presentation.
N2. Lab.
N3. Description of results using computer graphics programs.
N4. Consultations.

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| F1 | PEU_W01-W02 | Colloquium |
| F2 | PEU_U01-U03<br><br>PEU_K01-K03 | Preparation of a computational project |
| P = (F1+F2)/2 | | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

[1] Joaquim P. Marques de Sá., Applied Statistics Using SPSS, STATISTICA, MATLAB and R, Springer Berlin, Heidelberg, 2007
[2] Lindsey, J.K., Introduction to Applied Statistics. Oxford University Press,2003

**SECONDARY LITERATURE:**

[1] Statistica: przewodnik. StatSoft, Kraków, 2011
[2] T. Greber, Statystyczne sterowanie procesami - doskonalenie jakości z pakietem STATISTICA, Kraków, 2000
[3] B. Kacprzyński, Planowanie eksperymentów : podstawy matematyczne, Wydawnictwa Naukowo-Techniczne, 1974

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

**KONRAD MATYJA,** konrad.matyja@pwr.edu.pl

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

**SUBJECT CARD**

**Name of subject in Polish:** Praca dyplomowa I
**Name of subject in English:** Graduate laboratory I
**Main field of study (if applicable):**
**Specialization (if applicable):**
**Profile:** academic
**Level and form of studies:** 2nd level, full-time
**Kind of subject:** obligatory
**Subject code W03W03-SM1054D, W03W03-SM2054D**
**Group of courses** NO

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | | | 60 | | |
| Number of hours of total student workload (CNPS) | | | 150 | | |
| Form of crediting (Examination / crediting with grade) | | | crediting with grade | | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | | | 6 | | |
| including number of ECTS points for practical classes (P) | | | 6 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | 3 | | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1.
2.

**SUBJECT OBJECTIVES**

C1 Developing the ability to select and analyze sources of knowledge, including scientific literature
C2 Developing the ability to create a written study on the topic of the diploma thesis
C3 Expanding the skills of planning and conducting scientific work

**SUBJECT EDUCATIONAL EFFECTS**

In relation to knowledge:

PEU_W01 – knows the types of sources of scientific and professional knowledge,
PEU_W02 – has in-depth knowledge of the topic of the diploma thesis

In relation to skills:

PEU_U01 – is able to collect information useful for learning about a specific issue and preparing for the completion of a diploma thesis
PEU_U02 – is able to critically analyze the collected information in a form written on a selected scientific or practical issue.
PEU_U03 – (optional) is able to plan and carry out experiments/design work as well as develop the results and draw conclusions from their achievements and plan further work

In relation to social competences:

PEU_K01 – is ready to critically evaluate knowledge obtained from various sources
PEU_K02 – is ready to comply with the principles of professional ethics and respect copyrights

**PROGRAMME CONTENT**

| | **Laboratory** | **Number of hours** |
|---|---|---|
| Lab 1-Lab15 | Individual student work on a selected topic according to the schedule agreed with the diploma thesis supervisor | 60 |
| | Total hours | 60 |

**TEACHING TOOLS USED**

N1. consultations

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P | PEU_W01 – PEU_W02<br>PEU_U01 –PEU_U03<br>PEU_K01 – PEU_K02 | assessment of student work based on progress in completing the diploma thesis |

**PRIMARY AND SECONDARY LITERATURE**

Scientific and professional literature indicated by the course tutor and/or found by the student.

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

Supervisors of individual diploma thesis topics
Subject card preparation:
Piotr Rutkowski, piotr.rutkowski@pwr.edu.pl

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

**SUBJECT CARD**

**Name of subject in Polish:** Praca dyplomowa II
**Name of subject in English:** Graduate laboratory II
**Main field of study (if applicable):**
**Specialization (if applicable):**
**Profile:** academic
**Level and form of studies:** 2nd level, full-time
**Kind of subject:** obligatory
**Subject code W03W03-SM1055D, W03W03-SM2055D**
**Group of courses** NO

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | | | 210 | | |
| Number of hours of total student workload (CNPS) | | | 500 | | |
| Form of crediting (Examination / crediting with grade) | | | crediting with grade | | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | | | 20 | | |
| including number of ECTS points for practical classes (P) | | | 20 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | 9,5 | | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1.

**SUBJECT OBJECTIVES**

C1 implementation of a research project
C2 written preparation of the diploma thesis

**SUBJECT EDUCATIONAL EFFECTS**

In relation to knowledge:
PEU_W01 – knows the types of sources of scientific and professional knowledge
PEU_W02 – has advanced knowledge of the topic of the diploma thesis

In relation to skills:
PEU_U01– is able to carry out experiments / develop a project in accordance with the developed work plan

PEU_U02 – is able to compare information obtained from sources of knowledge with the results of research, verify the results of own research, draw conclusions and plan further work
PEU_U03 – is able to develop the results of his/her work on a selected topic and present them in the form of a diploma thesis

In relation to social competences:
PEU_K01 – is ready to critically evaluate the obtained results of research work on a selected topic
PEU_K02 – is ready to comply with the principles of professional ethics and respect copyrights

**PROGRAMME CONTENT**

| | **Laboratory** | **Number of hours** |
|---|---|---|
| Lab 1-Lab15 | Individual student work on a selected topic according to the schedule agreed with the diploma thesis supervisor | 210 |
| | Total hours | 210 |

**TEACHING TOOLS USED**

N1. consultations

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P | PEU_W01 – PEU_W02<br>PEU_U01 – PEU_U03<br>PEU_K01 – PEU_K02 | assessment of student work based on progress in completing the diploma thesis |

**PRIMARY AND SECONDARY LITERATURE**

Scientific and professional literature indicated by the course tutor and/or found by the student.

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

Supervisors of individual diploma thesis topics
Subject card preparation:
Piotr Rutkowski, piotr.rutkowski@pwr.edu.pl

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

**SUBJECT CARD**

**Name of subject in Polish:** Proseminarium
**Name of subject in English:** Graduation proseminar
**Main field of study (if applicable):**
**Specialization (if applicable):**
**Profile:** academic
**Level and form of studies:** 2nd level, full-time
**Kind of subject:** obligatory
**Subject code W03W03-SM1053S, W03W03-SM2053S**
**Group of courses** NO

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | | | | | 15 |
| Number of hours of total student workload (CNPS) | | | | | 25 |
| Form of crediting (Examination / crediting with grade) | | | | | crediting with grade |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | | | | | 1 |
| including number of ECTS points for practical classes (P) | | | | | 1 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | | 0,7 |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1.
2.
3.

\

**SUBJECT OBJECTIVES**

C1
C2

**SUBJECT EDUCATIONAL EFFECTS**

In relation to knowledge:
PEU_W01 – has knowledge of research topics related to the studied field of study conducted in organizational units of the Faculty of Chemistry

In relation to skills:

PEU_U01 – can take an active part in discussions on scientific topics

In relation to social competences:
PEU_K01 – is aware of the need to improve their competences in the field of research within the field of study

**PROGRAMME CONTENT**

| | **Seminar** | **Number of hours** |
|---|---|---|
| Semin 1-15 | Discussion of the topics of diploma theses by employees of the Faculty's units conducting research related to the field of study;<br>Presentation of research and analytical laboratories in the Faculty's units;<br>Discussion of the rules for selecting the topics of diploma theses and the rules for implementing/passing the "Diploma Thesis" courses | 15 |
| | Total hours | 15 |

**TEACHING TOOLS USED**

N1. Presentation
N2. Discussion
N3. Consultations

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P | PEU_W01<br>PEU_U01<br>PEU_K01 | Attendance at classes, participation in discussions - assessed by the people conducting the classes |

**PRIMARY AND SECONDARY LITERATURE**

N/A

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

Chairman of the study program committee

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

**SUBJECT CARD**

**Name of subject in Polish:** Przedmiot kierunkowy wybieralny
**Name of subject in English:** Elective course
**Main field of study (if applicable):**
**Specialization (if applicable):**
**Profile:** academic
**Level and form of studies:** 2nd level, full-time
**Kind of subject:** elective
**Subject code …….**
**Group of courses** NO

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | | | |
| Number of hours of total student workload (CNPS) | 25 | | | | |
| Form of crediting (Examination / crediting with grade) | Zaliczenie na ocenę | | | | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | 2 | | | | |
| including number of ECTS points for practical classes (P) | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1,3 | | | | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1.
2.
3.

**SUBJECT OBJECTIVES**

C1 Familiarizing the student with advanced issues in the field of chemical sciences (including biotechnology) and/or materials engineering and/or chemical engineering (including chemical technology)

**SUBJECT EDUCATIONAL EFFECTS**

In relation to knowledge:
PEU_W01 – Knows and is able to describe the basic phenomena and processes occurring in the life cycle of devices, objects and technical systems.

PEU_W02 – has in-depth knowledge of development trends and new achievements in the field of chemical engineering and technology and related sciences

In relation to social competences:

PEU_K01 – is ready to critically evaluate the knowledge acquired and the content received

PEU_K02 – is aware of the role of a technical university graduate and the need to maintain the ethos of the engineering profession

**PROGRAMME CONTENT**

| | **Lecture** | **Number of hours** |
|---|---|---|
| Lec 1-Lec 15 | To familiarize students with advanced concepts, theories describing phenomena, operations and processes occurring in living and inanimate systems, as well as with the latest trends in chemical sciences, chemical engineering and related sciences. Issues presented in an elective subject, depending on the field studied, may include, among others:<br>- adsorbents in environmental protection and industry<br>- alternative and renewable energy sources, renewable raw materials in industry, recycling technologies<br>- technical security<br>- medical and pharmaceutical chemistry<br>- chemistry of coordination compounds<br>- chemistry of fragrance compounds<br>- physical chemistry of chemical processes and products<br>- chemistry, engineering and technology of materials (polymer, carbon, ceramic, metallic) and composites<br>- technologies of dispersed systems<br>- catalysts and catalysis in industry<br>- instrumental methods in chemistry<br>- physicochemical description of simple and complex systems<br>- from the borderline of biology and medicine, describing the biological and biochemical basis of the functioning of organisms, including chemical and biochemical processes at the cellular and molecular level<br>- industrial aspects of biotechnology<br>- recycling of precious metals<br>- issues of technological process and quality management, principles of investing and operating chemical technologies<br>- modern chemical technologies<br>- biotechnology development trends<br>- basics of spectroscopic methods,<br>- bioelectrochemical systems<br>- issues related to sustainable development<br>- characteristics of the biotechnology and chemical industry in Poland and in the world | 30 |
| | Total hours | 30 |

**TEACHING TOOLS USED**

N1. Presentation

N2. Discussion

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P | PEU_W01- PEU_W02 PEU_K01- PEU_K02 | Writing test (to pass minimum 50% of points) |

| **PRIMARY AND SECONDARY LITERATURE** |
|---|
| [1] Literature is provided during the first classes by the teachers of the elective subject |
| **SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)** |
| Chairman of study program committee |

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

**SUBJECT CARD**

| | |
|---|---|
| Name of subject in Polish: | Pozyskiwanie danych naukowo technicznych |
| Name of subject in English: | Retrieval of Scientific and Technological Resources |
| Main field of study (if applicable): | Chemical engineering and Technology |
| Specialization (if applicable): | |
| Profile: | practical |
| Level and form of studies: | 2nd level |
| Kind of subject: | obligatory |
| Subject code: | W03CET-SM2005C |
| Group of courses: | NO |

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | | 15 | | | |
| Number of hours of total student workload (CNPS) | | 25 | | | |
| Form of crediting (Examination / crediting with grade) | | Crediting with grade | | | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | | 1 | | | |
| including number of ECTS points for practical classes (P) | | 1 | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | 0,6 | | | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Basic computer skills

**SUBJECT OBJECTIVES**

C1 Familiarization with technical standards and data
C2 Familiarization with scientific databases (Scopus, Web of Science, Google Scholar)
C3 Familiarization with specific databases (Reaxys, Chemspider, PDB, Mycobank)
C4 Familiarization with patent information, principles of patenting and patent protection

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
PEU_W01 Be able to search for information in scientific databases and retrieve scientific articles
PEU_W02 Be able to find patent information
relating to skills:
PEU_U01 Be able to write a patent application

| |
|---|
| PEU_U02 Be able to prepare a report on the current state of knowledge in a given field of science<br>relating to social competences:<br>PEU_K01 Is able to work in a group<br>PEU_K02 Is aware of the importance of acquired theoretical and practical knowledge<br>PEU_K03 Is able to present the results of his/her work |

| **PROGRAMME CONTENT** | | |
|---|---|---|
| **Project** | | **Number of hours** |
| Cw1 | Introduction to the class, discussion of the essence of scientific and technical information | 1 |
| Cw2 | Resources of library, standardization and patent databases | 2 |
| Cw3 | Working with databases (Web of Science, Scopus, Google Scholar) | 2 |
| Cw4 | Working with specialized databases (PDB, Mycobank, Chemspider, Reaxys) | 2 |
| Cw5 | Structure and methodology of creating patent applications | 2 |
| Cw6 | Formulating the topic and scope of the project | 2 |
| Cw7 | Partial evaluation of projects | 2 |
| Cw8 | Project presentation | 2 |
| | Total hours | 15 |

| **TEACHING TOOLS USED** |
|---|
| N1. Presentation<br>N2. Group work<br>N3. Consultation |

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| F1 Project | PEU_W01<br>PEU_W02<br>PEU_U01<br>PEU_U02<br>PEU_K01<br>PEU_K02<br>PEU_K03 | -attendance during the course<br>-project |
| P = F1= 10 pkt.<br><br>9,5 - 10 pkt. + bdb<br>9,0 – 9,4 pkt. bdb<br>8,0 – 8,9 pkt. + db<br>7,0 – 7,9 pkt. db | | |

6,0 – 6,9 pkt. + dst
5,0 – 5,9 pkt. dst

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

[1] H. Kara *Research and Evaluation for Busy Students and Practitioners: A Time-Saving Guide*
[2] C. Manning, P. Raghavan, H. Schutze *An Introduction to Information Retrieval*
[3] D. Lewandowski *Web Search Engine Research* (Library and Information Science, 4)

**SECONDARY LITERATURE:**

[1] A.Szewc *Informacja naukowo-techniczna*

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

Mateusz Jackowski, mateusz.jackowski@pwr.edu.pl

Zał. nr 5 do ZW 78/2023
Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

**SUBJECT CARD**

**Name of subject in Polish:** Zespołowy projekt badawczy
**Name of subject in English:** **Scientific team project**
**Main field of study (if applicable):** Chemical Engineering and Technology
**Specialization (if applicable):** Advanced Chemical Technology
**Profile:** academic
**Level and form of studies:** 2nd level, full-time
**Kind of subject:** obligatory
**Subject code:** **W03CET-SM2019P**
**Group of courses:** NO

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | | | | 60 | |
| Number of hours of total student workload (CNPS) | | | | 150 | |
| Form of crediting (Examination / crediting with grade) | | | | crediting with grade | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | | | | 6 | |
| including number of ECTS points for practical classes (P) | | | | 6 | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | 3 | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

n/a

**SUBJECT OBJECTIVES**

C1 preparation of research project
C2 deepening teamwork skills

**SUBJECT EDUCATIONAL EFFECTS**

In relation to skills:
PEU_U01 – is able to plan, carry out experiments / develop a project together with a team in accordance with the developed work plan
PEU_U02 – can initiate a discussion and actively participate in it
PEU_U03 – is able to develop the results of his/her work on a selected topic and present them in the form of a presentation
In relation to social competences:
PEU_K01 – is ready to critically evaluate the obtained results of research work PEU_K02 – is ready to comply with the principles of professional ethics and respect copyrights

| PROGRAMME CONTENT | | |
|---|---|---|
| **Laboratory** | | **Number of hours** |
| Pr1 | Discussion of the principles of project implementation and conditions for passing the course. Basics of PBL (project-based learning). | 4 |
| Pr2-7 | Organization of group work. Division of roles and tasks. Development of the project's goal and assumptions, development of a work schedule. Collecting data for the project. Laboratory work (computer laboratory, technology laboratory, chemical laboratory) on a selected topic according to the schedule agreed with the project supervisor - stage I. | 26 |
| Pr8 | Presentation of progress on the project | 2 |
| Pr9-14 | Laboratory work (computer laboratory, technology laboratory, chemical laboratory) on a selected topic according to the schedule agreed with the project supervisor - stage II. Preparation of the report. | 26 |
| Pr15 | Presentation (defense) of the project. | 2 |
| | Total hours | 60 |

| TEACHING TOOLS USED |
|---|
| N1. Consultations<br>N2. Multimedia presentation<br>N3. Discussion |

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P | PEU_U01 – PEU_U03<br>PEU_K01 | assessment of the student's individual work during the project implementation<br>assessment of group work<br>evaluation of the report and presentation (project defense) |

| PRIMARY AND SECONDARY LITERATURE |
|---|
| Scientific and professional literature indicated by the course tutor and/or found by the student. |
| **SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)** |
| Supervisor of specialization |

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

**SUBJECT CARD**

**Name of subject in Polish:** Seminarium dyplomowe
**Name of subject in English:** Graduation seminar
**Main field of study (if applicable):**
**Specialization (if applicable):**
**Profile:** academic
**Level and form of studies:** 2nd level, full-time
**Kind of subject:** obligatory
**Subject code:** **W03W03-SM1056S, W03W03-SM2056S**
**Group of courses:** NO

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | | | | | 15 |
| Number of hours of total student workload (CNPS) | | | | | 50 |
| Form of crediting (Examination / crediting with grade) | | | | | crediting with grade |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | | | | | 2 |
| including number of ECTS points for practical classes (P) | | | | | 2 |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | | | | | 0,7 |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

n/a

**SUBJECT OBJECTIVES**

C1 development of students' social competences in presenting the results of their diploma thesis, initiating discussions and actively participating in them

**SUBJECT EDUCATIONAL EFFECTS**

**relating to knowledge:**
PEU_W01 – has in-depth knowledge of the topic of the diploma thesis
**relating to skills:**

PEU_U01 – is able to collect and verify information necessary to learn about the selected research topic
PEU_U02 – is able to draw conclusions from the results of one's own research in relation to literature sources
PEU_U03 – is able to publicly present the results of his research and defend them during public discussion
PEU_U04 – is able to transfer knowledge to others
**relating to social competences:**
PEU_K01 – is aware of the importance of knowledge, including its critical analysis
PEU_K02 – is ready to deepen knowledge and skills, and, if necessary, use the help of experts

| **PROGRAMME CONTENT** | | |
|---|---|---|
| **Seminar** | | **Number of hours** |
| Se 1 | Discussion of the diploma process in the field of study | 1 |
| Se 2 – Se 15 | Presenting a multimedia presentation and participating in the discussion | 14 |
| | Total hours | 15 |

| **TEACHING TOOLS USED** |
|---|
| N1. Presentation<br>N2. Discussion<br>N3. Consultations |

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P | PEU_W01<br>PEU_U01 –PEU_U04<br>PEU_K01 – PEU_K02 | assessment based on the presentation and activity in discussions |

| **PRIMARY AND SECONDARY LITERATURE** |
|---|
| N/A |
| **SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)** |
| Chairman of the program committee for the relevant field of study<br>Card preparation:<br>Piotr Rutkowski, piotr.rutkowski@pwr.edu.pl |

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY OF CHEMISTRY

**SUBJECT CARD**

**Name of subject in Polish** Zjawiska powierzchniowe i kataliza heterogeniczna

**Name of subject in English:** Surface Phenomena and Heterogenous Catalysis

**Main field of study (if applicable): Chemical Engineering and Technology**
**Specialization (if applicable): Advanced Chemical Technologies**
**Profile: academic**
**Level and form of studies: 2nd level, full-time**
**Kind of subject: obligatory**
**Subject code W03CET-SM2013W, W03CET-SM2013L, W03CET-SM2013S**
**Group of courses NO**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 30 | | 15 |
| Number of hours of total student workload (CNPS) | 75 | | 50 | | 25 |
| Form of crediting (Examination / crediting with grade) | Examination | | Crediting with grade | | Crediting with grade |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | 3 | | 2 | | 1 |
| including number of ECTS points for practical classes (P) | | | 2 | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1,2 | | 1,2 | | 0,6 |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Knowledge of English language (B2 level).
2. The knowledge of organic and inorganic chemistry.
3. The knowledge of physical chemistry.

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**SUBJECT OBJECTIVES**

C1. To fmilalise the student with basic concept of heterogeneous catalysis.
C2. To familiarise the student with phenomena occurring on catalyst surface.
C3. To train the student in different methods of catalyst preparation, ways of its physicochemical characterization and determination of its performance.
C4. To bring the student up to date with the catalytic processes applied in the chemical, fuel and energy industry.
C5. To familiarise the student with the state-of-the-art catalytic processes for environmental protection.

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:

PEU_W01 The student knows the fundamental definitions used in heterogeneous catalysis.
PEU_W02 The student understands the surface phenomena occurring on the catalyst during

reaction.
PEU_W03 The student understands the mechanisms of catalytic reaction.
PEU_W04 The student knows the methods of catalysts preparation and their characterization.
PEU_W05 The student knows the main problems occurring during catalytic processes linked to catalyst deactivation.
PEU_W06 The student can describe popular types of catalysts and reactions used in different branches of chemical industry.
PEU_W07 The student can describe basic catalytic processes used in different branches of chemical industry (i.e., for production of chemicals, fuels, energy and in automotive sector).

relating to skills:
PEU_U01 The student can synthesize solid catalyst on the grounds of literature data.
PEU_U02 The student is able to carry out the catalytic test of specific reaction, calculate the conversions, selectivities and yields of reaction products.
PEU_U03 The student can determine the chemical composition of catalyst and describe its structure features on the basis of results of its characterisation.
PEU_U04 The student is able to prepare a multimedia presentation, perform in public, and share the knowledge with the group.
PEU_U05 The student can work with research data provided through journals, books, and patents.
PEU_U06 The student can determine the role of the active sites required for the individual reaction.
PEU_U07 The student is able to select research methods regarding the characteristics of a given group of heterogeneous catalysts and determining their activity.

relating to social competences:
PEU_K01 The student is aware of the need for continuous training.
PEU_K02 The student develops the ability to behave properly in their learning and working environment, and beyond those.
PEU_K03 The student is able to work with others and develops their leadership skills.
PEU_K04 The student is aware of the non-technical effects associated with chemical processes.

**PROGRAMME CONTENT**

| **Lecture** | | **Number of hours** |
|---|---|---|
| Lec 1 | Catalysis and catalyst - introduction. The significance of catalysis in everyday life. Catalysis in industry. Description of types of catalysis. Definitions of conversion, selectivity, activity, yield, turnover frequency. Thermodynamics and kinetics of catalytic reaction. Activation energy, equilibrium constant, rate constant, reaction order. | 4 |
| Lec 2 | Reaction steps in heterogeneous catalysis. active sites, reaction mechanism (Eley-Rideal, Langmuir-Hinshelwood). | 2 |
| Lec 3 | Adsorption process. Types of adsorption. Energy of adsorption. The significance of surface structure of the catalyst for adsorption process. | 2 |
| Lec 4 | Crystallographic structure of metals and metal oxides. Classification of crystal imperfections and their impact on catalyst activity. | 2 |
| Lec 5 | Active sites. Crystallography of active sites, geometrical factor, saturation of active sites. The acid-base character of catalyst surface. Electronic properties of active sites. Bifunctional catalysts. | 2 |

| | | |
|---|---|---|
| Lec 6 | Preparation of solid catalysts. Description of sol-gel method, impregnation, precipitation and co-precipitation. Supported catalyst. | 4 |
| Lec 7 | Characterization of solid catalyst. Surface structure and chemical composition of catalysts - description of methods and procedures of solid catalysts characterization. | 2 |
| Lec 8 | Catalyst deactivation. Poisoning, formation of deposits, thermal degradation. Prevention of catalyst deactivation. Catalyst regeneration. | 2 |
| Lec 9 | Catalysis for the production of chemicals. | 2 |
| Lec 10 | Catalysis for the production of fuels. | 4 |
| Lec 11 | Catalysis in environmental protection. Desulfurization, reduction of NOx, methane reforming, VOC's oxidation. | 4 |
| | Total hours | 30 |

| **Classes** | | **Number of hours** |
|---|---|---|
| Cl 1 | | |
| Cl 2 | | |
| Cl 3 | | |
| Cl 4 | | |
| .. | | |
| | Total hours | |

| **Laboratory** | | **Number of hours** |
|---|---|---|
| Lab 1 | Introduction. | 2 |
| Lab 2 | Preparation of supported catalysts via wetness incipient impregnation method. | 4 |
| Lab 3 | Preparation of Metalorganic frameworks via ultrasound assisted solvothermal method. | 4 |
| Lab 4 | Determination of physicochemical properties of catalysts (determination of phase composition, morphology, textural properties, thermal stability and surface chemistry using XRD, STEM, $N_2$ sorption, TGA and FTIR). | 8 |
| Lab 5 | Diffusion in catalytic bed. | 4 |
| Lab 6 | Catalytic processes in the fixbed flow reactor - determiantion of the activity of heterogeneous catalyst in the reaction of synthesis gas production. | 4 |
| Lab 7 | Catalytic processes in the batch reactor - determiantion of the activity of MOFs in the reaction of $CO_2$ conversion. | 4 |
| | Total hours | 30 |

| **Project** | | **Number of hours** |
|---|---|---|
| Proj 1 | | |
| Proj 2 | | |
| Proj 3 | | |
| Proj 4 | | |
| … | | |
| | Total hours | |

| **Seminar** | | **Number of hours** |
|---|---|---|
| Semin 1 | Methods for determining catalytic activity. | 2 |

| | | |
|---|---|---|
| Semin 2 | Temperature-programmed techniques for assessing the surface properties of the catalysts. | 2 |
| Semin 3 | Zeolites – structure, properties and application in adsorption and catalysis. | 2 |
| Semin 4 | Oxidation reactions on oxide catalysts. | 2 |
| Semin 5 | Reactions in the hydrogen presence on metallic catalysts. | 2 |
| Semin 6 | Reactions over acid-base catalysts. | 2 |
| Semin 7 | Advanced materials in catalysis and adsorption. | 3 |
| | Total hours | 15 |

## TEACHING TOOLS USED

N1. Lecture with a multimedia presentation.
N2. Executive instructions for laboratory classes.
N3. Laboratory classes carried out with the use of research facilities.
N4. Individual consultations with the student.

## EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P (lecture) | PEU_W01-PEU_W07 | Grade from the exam:<br>grade 2.0: 0-50%<br>grade 3.0: 51- 60%<br>grade 3.5: 61-70%<br>grade 4.0: 71- 80%<br>grade 4.5: 81- 90%<br>grade 5.0: 91- 100% |
| F1 (laboratory) | PEU_U01-PEU_U03 | Grade form the test (T) |
| F2 (laboratory) | PEU_U01-PEU_U03, PEU_K01-PEU_K04 | Grade from the report (R) |
| P (seminar) | PEU_U04-PEU_U07, PEU_K01-PEU_K04 | Grade of the student's presentation (S). |
| P (laboratory) Grade = 0.5xT + 0.5xR | | |

## PRIMARY AND SECONDARY LITERATURE

### PRIMARY LITERATURE:


[1] „Handbook of Heterogeneous Catalysis", Editors: G. Erti, H. Knözinger, F. Schüth, J. Weitkamp, 2014, Wiley-VCH, ISBN: 9783527610044.
[2] J. Ross „Heterogeneous catalysis. Fundamentals and Applications." 2011, Elsevier, ISBN: 978-0-444-53363-0.
[3] „Heterogeneous Catalysis and Fine Chemicals II", Editors: M. Guisnet et al.,1991, Elsevier, 978-0-444-88514-2.


### SECONDARY LITERATURE:


[1] G. Rothenberg „Catalysis: Concepts and Green Applications" 2008, Wiley-VCH, ISBN 978-3-527-31824-7.
[2] M. Ziółek, I. Nowak „Kataliza heterogeniczna. Wybrane zagadnienia" Wydawnictwo Naukowe UAM
[3] Electrionic sources / Elsevier


## SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)


Dr inż. Agata Łamacz, agata.lamacz@pwr-edu.pl

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

**SUBJECT CARD**

**Name of subject in Polish:** Trendy w inżynierii i technologii chemicznej
**Name of subject in English:** Trends in Chemical Engineering and Technology
**Main field of study (if applicable):** Chemical Engineering and Technology
**Specialization (if applicable):**
**Profile:** academic
**Level and form of studies:** 2nd level, full-time
**Kind of subject:** obligatory
**Subject code:** **W03CET-SM2004W**
**Group of courses:** NO

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | | | |
| Number of hours of total student workload (CNPS) | 50 | | | | |
| Form of crediting (Examination / crediting with grade) | Zaliczenie na ocenę | | | | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | 2 | | | | |
| including number of ECTS points for practical classes (P) | | | | | |
| including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU) | 1,2 | | | | |

*delete as not necessary

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

n/a

**SUBJECT OBJECTIVES**

C1 To familiarize the student with the latest trends and achievements in chemical engineering and technology

**SUBJECT EDUCATIONAL EFFECTS**

In relation to knowledge:

PEU_W01 – has in-depth knowledge of development trends and new achievements in the field of chemical engineering and technology and related sciences

PEU_W02 – has in-depth knowledge of the latest materials, apparatus and devices used in chemical processes at various scales

In relation to social competences:
PEU_K01 – is ready to critically evaluate the knowledge acquired and the content received
PEU_K02 – is aware of the role of a technical university graduate and the need to maintain the ethos of the engineering profession

**PROGRAMME CONTENT**

| | **Lecture** | **Number of hours** |
|---|---|---|
| Wy1-W7 | A collection of current topics reflecting the diversity of contemporary trends in chemical engineering. Presenting the latest scientific achievements in the field of chemical engineering. | 14 |
| Wy8-Wy14 | A collection of current topics reflecting the diversity of contemporary trends in chemical technology. Presenting the latest scientific achievements in the field of chemical technology. | 14 |
| Wy15 | Summary lecture with discussion. | 2 |
| | Total hours | 30 |

**TEACHING TOOLS USED**

N1. Presentation
N2. Discussion

**EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT**

| **Evaluation** (F – forming during semester), P – concluding (at semester end) | Learning outcomes code | Way of evaluating learning outcomes achievement |
|---|---|---|
| P | PEU_W01-PEU_W02<br>PEU_K01- PEU_K02 | Writing test (to pass minimum 50% of points) |

**PRIMARY AND SECONDARY LITERATURE**

[1] Presentations
[2] Supporting literature provided during classes by the teachers

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

heads of specialties: Advanced chemical engineering, Advanced chemical technology