Zał. Nr 1 do ZW 78/2023

PROGRAM OF STUDIES

FACULTY: **Chemistry**

MAIN FIELD OF STUDY: **Advanced Nano and Biomaterials - MONABIPHOT**

BRANCH OF SCIENCE: **engineering and technology/ natural sciences**

DISCIPLINES: D1 **materials engineering** (major discipline)

D2* **chemical sciences**

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

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

PROFILE: **general academic**

LANGUAGE OF STUDY: **English**

Content:

1. Assumed learning outcomes – attachment no. 1 to the program of studies
2. Program of studies description – attachment no. 2 to the program of studies

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: **Advanced Nano and Biomaterials - MONABIPHOT**
EDUCATION LEVEL: **second-level studies**
PROFILE: **general academic**

Location of the main-field-of study:

Branch of science: **engineering and technology** Discipline: **materials engineering**

Branch of science: **natural sciences** Discipline: **chemical sciences**

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 Advanced Nano and Biomaterials – MONABIPHOT(an)

before the underscore:
K – directional learning outcomes,
2 – second cycle of studies
A – general academic profile
an – 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 **Advanced Nano and Biomaterials - MONABIPHOT** 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 6 / 7* levels of PRK	Characteristics for qualifications on 6 and 7 levels of PRK, enabling acquiring engineering competences
KNOWLEDGE (W)				
K2Aan_W01	Has in-depth knowledge of the composition, method of synthesis and characterization of nanomaterials and biomaterials. Has knowledge of the applications of nanomaterials and biomaterials as well as the selection of the appropriate method for characterizing this type of materials.	P7U_W	P7S_WG	P7S_WG_INŻ
K2Aan_W02	Knows methods of producing metallic, polymeric and biomaterials. Understands the impact of various additives on the properties of manufactured materials.	P7U_W	P7S_WG	P7S_WG_INŻ
K2Aan_W03	Has structured knowledge of the physical fundamentals of the interaction of electric fields, magnetic fields and electromagnetic waves with a liquid crystal. Has knowledge of the classification of liquid crystals in terms of their structure, symmetry, factor causing the formation of mesophases and spatial structures.	P7U_W	P7S_WG	P7S_WG_INŻ
K2Aan_W04	Has in-depth knowledge of modern methods of imaging materials using various microscopic techniques.	P7U_W	P7S_WG	P7S_WG_INŻ
K2Aan_W05	Has basic knowledge of selecting and fitting a mathematical model to experimental data.	P7U_W	P7S_WG	
K2Aan_W06	Knows the factors determining the mechanical and functional properties of the main engineering materials: metals, alloys, polymers and nanomaterials, knows their structure, examples of applications and the impact of additives on the properties of these materials.	P7U_W	P7S_WG	P7S_WG_INŻ
K2Aan_W07	Knows issues of the construction of lasers and other light sources and the generation of electromagnetic radiation in selected spectral ranges. Knows the effects of EM radiation on matter.	P7U_W	P7S_WG	P7S_WG_INŻ
K2Aan_W08	Has structured, theoretically based general knowledge covering key issues in the field of spectroscopy. Knows the light sources used in spectroscopy. Knows new trends in spectroscopy.	P7U_W	P7S_WG	

K2Aan_W09	Knows the concepts and principles of intellectual property protection, patent protection and copyright.	P7U_W	P7S_WK	
K2Aan_W10	Has knowledge about authorized inference methods.	P7U_W	P7S_WK	
K2Aan_W11	Knows the basic concepts of entrepreneurship and the functioning of an enterprise. Has basic knowledge of management processes and related organizational structures. Knows the basic elements of organizing a business.	P7U_W	P7S_WK	P7S_WK_INŻ
K2Aan_W12	Has in-depth knowledge of the technology of combining materials using physical and chemical methods.	P7U_W	P7S_WG	P7S_WK_INŻ
K2Aan_W13	Has knowledge of the chemical and physical characteristics of materials and their impact on their functional properties	P7U_W	P7S_WG	
K2Aan_W14	Understands the connection between the technology of obtaining materials and composites and their structure and properties.	P7U_W	P7S_WG	
K2Aan_W15	Has general knowledge of research conducted in modern materials engineering and nanomaterials engineering.	P7U_W	P7S_WG	
K2Aan_W16	Lists and explains advanced processes in creating new materials and current trends in their development.	P7U_W	P7S_WG	
K2Aan_W17	Has in-depth knowledge of mathematical and IT tools enabling understanding, quantitative description, modeling and design of materials or engineering objects or chemical/biotechnological processes.	P7U_W	P7S_WG	P7S_WG_INŻ
K2Aan_W18	Has in-depth knowledge of exact and natural sciences as well as engineering and technology, allowing the use of methods and concepts necessary to describe materials, chemical or biotechnological processes.	P7U_W	P7S_WG	P7S_WG_INŻ
SKILLS (U)				
K2Aan_U01	Is able to assess the behavior of nanomaterials, biomaterials and polymers in various conditions.	P7U_U	P7S_UW	P7S_UW_INŻ
K2Aan_U02	Is able to design experiments for nanomaterials, polymeric materials and biomaterials.	P7U_U	P7S_UW P7S_UK	P7S_UW_INŻ
K2Aan_U03	Is able to conduct literature research on a specific scientific and research problem. Has basic skills in planning and conducting scientific research.	P7U_U	P7S_UU P7S_UK	
K2Aan_U04	Is able to conduct scientific experiments, develop and interpret their results and relate them to appropriate theories or scientific hypotheses. Is able to determine directions for further learning and implement the self-education process. Is able to apply the principles of safe work in a chemical laboratory.	P7U_U	P7S_UU P7S_UK P7S_UW	P7S_UW_INŻ
K2Aan_U05	Is able to present the goals and results of his scientific work in the form of an oral presentation, using modern information and communication techniques. Is able to prepare, in Polish or a foreign	P7U_U	P7S_UK P7S_UW	P7S_UW_INŻ

	language, a scientific study presenting the results of his/her own scientific research.			
K2Aan_U06	Has linguistic resources appropriate for a specialized language and is able to use the specialized language in all linguistic activities to communicate in a professional environment in the field of study, understands foreign language texts in his field of study and is able to interpret them.	P7U_U	P7S_UW P7S_UK	
K2Aan_U07	Has language skills in the fields of science and scientific disciplines relevant to the field of study studied, in accordance with the requirements specified for levels A1/A2 and B2+ of the Common European Framework of Reference for Languages.	P7U_U	P7S_UW P7S_UK	
K2Aan_U08	Is able to think critically and argue his position.	P7U_U	P7S_UK	
K2Aan_U09	Is able to identify the priorities of his actions, both individually and when working in a group.	P7U_U	P7S_UW P7S_UO	
K2Aan_U10	Is able to independently plan and implement continuous training and guides others in this area	P7U_U	P7S_UU	
K2Aan_U11	Is able to determine the chemical, physicochemical and mechanical properties of materials and nanostructures	P7U_U	P7S_UW P7S_UK	
K2Aan_U12	Uses information technologies to solve tasks, including engineering ones. Selects and applies mathematical and IT methods/tools in planning, designing, optimizing and analyzing experiments, objects and chemical processes.	P7U_U	P7S_UW	P7S_UW_INŻ
K2Aan_U13	Is able to investigate photochemical phenomena occurring in nano and biomaterials.	P7U_U	P7S_UW P7S_UK	P7S_UW_INŻ
K2Aan_U14	Is able to conduct a research experiment in the field of liquid crystals.	P7U_U	P7S_UW P7S_UK	
K2Aan_U15	Is able to independently develop and present the state of knowledge based on scientific publications.	P7U_U	P7S_UW P7S_UK	
K2Aan_U16	Is able to independently perform material tests using advanced techniques, and is able to analyze and interpret the obtained results.	P7U_U	P7S_UW P7S_UK	P7S_UW_INŻ
K2Aan_U17	Applies microscopic techniques for qualitative and quantitative interpretation of chemical, physical and biological phenomena	P7U_U	P7S_UW P7S_UK	P7S_UW_INŻ
SOCIAL COMPETENCES (K)				
K2Aan_K01	is ready to critically evaluate his knowledge and received content.	P7U_K	P7S_KK	
K2Aan_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	
K2Aan_K03	understands the need to take initiatives, inspire and organize activities for the benefit of the socio-economic environment.	P7U_K	P7S_KO	
K2Aan_K04	cooperates responsibly in the group, taking on various roles, including managerial ones.	P7U_K	P7S_KR	

K2Aan_K05	is ready to comply with the principles of professional ethics and respect the law, including copyright.	P7U_K	P7S_KR	
K2Aan_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 P7S_KO	
K2Aan_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	
K2Aan_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: Advanced Nano and Biomaterials - MONABIPHOT	**Profile:** general academic
Level of studies: 2nd level studies (3 sem. 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 set out in the Order-"The conditions and procedures for recruitment" in the Technical University of Wroclaw***
1.5 Upon completion of studies graduate obtains professional degree of: ***magister inżynier***	*1.6 Graduate profile, employability:* *The alumnus has theoretical knowledge and skills enabling him to solve issues related to the design and characterization of modern materials, including nanomaterials, biomaterials and materials interacting with light. He/she has in-depth practical and theoretical knowledge of the field of advanced nano and biomaterials, he/she represents. Has the ability to interpret and quantitatively describe basic physicochemical phenomena, conduct laboratory and research work, and manage teams and organize the work of such*

	teams. He/she fluently speaks specialized language in the field of research on bio and nanomaterials as well as liquid crystals and polymers. He/she is prepared to start studies at the Doctoral School. The alumnus knows the basics of programming and uses the Internet efficiently.
1.7 Possibility of continuing studies: ***Possibility to apply for admission to the Doctoral School, postgraduate studies***	***1.8 Indicate connection with University's mission and its development strategy:*** *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* ***Advanced Nano and Biomaterials-Monabiphot*** *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.* *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 of science and technology in the field of innovative chemical processes and material technologies, (5) developing social competences, with particular emphasis on the development of skills*

[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

	teamwork, (6) developing the ability to work using the project method.

2. Detailed description

2.1 Total number of learning outcomes in the program of study: W (knowledge)= 18, U (skills) = 17, K (competences) = 8, W + U + K = 43

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

D1 26 (major) (this number must be greater than half the total number of learning outcomes)

D2 17

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 60% ECTS points

D2 40% 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)

70 pkt ECTS

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)

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

The labor market needs in the field of **Advanced Nano and Biomaterials - MONABIPHOT** are indirectly presented in this Study Program under the heading Profile of the graduate, employment opportunities. The preparation of graduates listed there is reflected, among others, in the following learning outcomes: (1) Knows methods of producing metallic, polymeric and biomaterials. Understands the influence of various additives on the properties of manufactured materials, (2) Has basic knowledge of the selection and adjustment of a mathematical model to experimental data., (3) Is able to assess the behavior of nanomaterials and biomaterials as well as polymers in various conditions, (4) Is able to design experiments for nanomaterials, polymeric materials and biomaterials. (5) Is able to independently perform material tests using advanced techniques, and is able to analyze and interpret the obtained results. The expected learning outcomes are in line with the current needs of the sector of design, production and processing of modern materials used in various industries. The learning outcomes are tailored in such a way that the graduate is ready to start working in companies dealing with quality control and characterization of manufactured/processed modern organic materials, liquid crystals, nanomaterials, biomaterials and polymeric materials.

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)

49,15 ECTS

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

Number of ECTS points for obligatory subjects	4
Number of ECTS points for optional subjects	0
Total number of ECTS points	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
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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)

Number of ECTS points for obligatory subjects	23
Number of ECTS points for optional subjects	32
Total number of ECTS points	55

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)

41 ECTS points

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

Verification and assessment of learning outcomes with reference to courses or groups of courses throughout the entire education cycle takes place in relation to the information contained in the subject cards (syllabuses).

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 tutors conducting classes with students. The basis of teaching and learning process are laboratory, seminar and project courses. Education in the field of studies is conducted in accordance with the principle of increasing the complexity of theoretical and practical tasks set for students. Modern teaching methods are implemented in the teaching practice, thanks to which the students' activity during the classes increases. Theoretical courses in the form of lectures and seminars are supplemented with project and laboratory classes, which include, among others: computer modelling and design, as well as conducting scientific research. The program is complemented by humanities and foreign language courses. The course (study programme) ends with a master thesis preparation and its defence checking the student's theoretical knowledge.

[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. 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 Subjectgroup of courses	Way[3] of crediting	Subjectgroup 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 Subjectgroup of courses	Way[3] of crediting	Subjectgroup 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 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 Subjectgroup of courses	Way[3] of crediting	Subjectgroup 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

4.1.1.4 *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 Subjectgroup of courses	Way[3] of crediting	Subjectgroup 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 Subjectgroup 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	W03ANB-SM2007L	Mathematical methods in planning and analysis of experiment			2			K2Aan_W05 K2Aan_W10 K2Aan_W17 K2Aan_U06 K2Aan_U08 K2Aan_U12	30	50	2		1,4	T	Z			P	PD
		Total			**2**				**30**	**50**	**2**		**1,4**					**2**	

4.1.2.2 *Physics* block

No.	Subject group of classes code	Name of Subjectgroup 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 Subjectgroup of courses	Way[3] of crediting	Subjectgroup 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																	

4.1.2.3 *Chemistry* block

No.	Subject group of classes code	Name of Subjectgroup 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 Subjectgroup of courses	Way[3] of crediting	Subjectgroup 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	W03ANB-SM2002W	Modern spectroscopy	2					K2Aan_W07 K2Aan_W08	30	50	2	2	1,3	T/Z	**E**		DN		PD
		Total	**2**						**30**	**50**	**2**	**2**	**1,3**		**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

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					
2		**2**			**60**	**100**	**4**	**2**	**2,7**

[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 Subjectgroup 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	Subjectgroup 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	W03ANB-SM2006W	Liquid crystals for photonics	2					K2Aan_W03 K2Aan_W15	30	75	3	3	1,3	T/Z	**E**		DN		K
2	W03ANB-SM2006L	Liquid crystals for photonics.			1			K2Aan_W03 K2Aan_U04 K2Aan_U11 K2Aan_U14	15	25	1	1	0,7	T	Z		DN	P	K
3	W03ANB-SM2005W	Modern polymers	2					K2Aan_W01 K2Aan_W15 K2Aan_W18	30	50	2		1,3	T/Z	Z				K
4	W03ANB-SM2004W	Bioorganic chemistry	2					K2Aan_W13 K2Aan_W14 K2Aan_W15	30	75	3	3	1,3	T/Z	**E**		DN		K
5	W03ANB-SM2003W	Biophotonics	1					K2Aan_W07 K2Aan_W13	15	50	2		0,65	T/Z	Z				K
6	W03ANB-SM2003S	Biophotonics.					2	K2Aan_W07 K2Aan_U05 K2Aan_U06 K2Aan_U08	30	50	2		1,4	T/Z	Z			P	K
7	W03ANB-SM2001W	Fluorescence spectroscopy and bioimaging	2					K2Aan_W07 K2Aan_W13	30	75	3	3	1,3	T/Z	Z		DN		K
8	W03ANB-SM2001C	Fluorescence spectroscopy and bioimaging.		1				K2Aan_U12 K2Aan_U17 K2Aan_U16	15	25	1	1	0,7	T/Z	Z		DN	P	K
9	W03ANB-SM2014W	Advanced functional materials	2					K2Aan_W02 K2Aan_W04 K2Aan_W06 K2Aan_W12 K2Aan_W16 K2Aan_W18	30	50	2	2	1,3	T/Z	**E**		DN		K

[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

10	W03ANB-SM2014S	Advanced functional materials.					2	K2Aan_W12 K2Aan_W15 K2Aan_U05 K2Aan_U06 K2Aan_U08 K2Aan_K07	30	50	2	2	1,4	T/Z	Z		DN	P	K
11	W03ANB-SM2013W	Advanced research methods in the engineering of materials	2					K2Aan_W07 K2Aan_W14	30	50	2	2	1,3	T/Z	**E**		DN		K
12	W03ANB-SM2013C	Advanced research methods in the engineering of materials		1				K2Aan_W14 K2Aan_U02 K2Aan_U11 K2Aan_K08	15	25	1	1	0,7	T/Z	Z		DN	P	K
13	W03ANB-SM2013L	Advanced research methods in the engineering of materials			1			K2Aan_W14 K2Aan_U02 K2Aan_U13 K2Aan_U16 K2Aan_K08	15	50	2	2	0,7	T	Z		DN	P	K
14	W03ANB-SM2012W	Organic electronics	1					K2Aan_W07 K2Aan_W13	15	25	1	1	0,65	T/Z	Z		DN		K
15	W03ANB-SM2012S	Organic electronics.					1	K2Aan_W13 K2Aan_W15 K2Aan_U05 K2Aan_U06 K2Aan_U08	15	25	1	1	0,7	T/Z	Z		DN	P	K
16	W03ANB-SM2011W	Nanomaterials	2					K2Aan_W06 K2Aan_W13 K2Aan_W18	30	50	2	2	1,3	T/Z	**E**		DN		K
17	W03ANB-SM2011S	Nanomaterials.					1	K2Aan_W13 K2Aan_W15 K2Aan_U05 K2Aan_U06 K2Aan_U08 K2Aan_K07	15	25	1	1	0,7	T/Z	Z		DN	P	K
18	W03ANB-SM2010W	Nanoscale physics	2					K2Aan_W04 K2Aan_W06 K2Aan_W12	30	50	2	2	1,3	T/Z	Z		DN		K
19	W03ANB-SM2010L	Nanoscale physics.			1			K2Aan_W12 K2Aan_U04 K2Aan_U09 K2Aan_U13 K2Aan_U16 K2Aan_K05	15	50	2	2	0,7	T	Z		DN	P	K

[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

20	W03ANB-SM2009L	Nonlinear optics for Chemists.			1			K2Aan_W07 K2Aan_U04	15	50	2	2	0,7	T	Z		DN	P	K
21	W03ANB-SM2008W	Laser and microscopic techniques in materials analysis	2					K2Aan_W02 K2Aan_W04 K2Aan_W12 K2Aan_W15	30	50	2	2	1,3	T/Z	Z		DN		K
22	W03ANB-SM2014L	Advanced functional materials..			6			K2Aan_W04 K2Aan_W12 K2Aan_U01 K2Aan_U04 K2Aan_U09 K2Aan_U10 K2Aan_U12 K2Aan_U13 K2Aan_U15 K2Aan_U16 K2Aan_U17	90	150	6	6	4,2	T	Z		DN	P	K
		Total	**20**	**2**	**10**		**6**		**570**	**1125**	**45**	**39**	**25,6**		**5**			**21**	

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]
lec	cl	lab	pr	sem					
20	**2**	**10**		**6**	**570**	**1125**	**45**	**39**	**25,6**

[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

4.2 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 Subjectgroup 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 Subjectgroup of courses	Way[3] of crediting	Subjectgroup 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	W03-SM2002BH	Managerial course I	1					K2Aan_K02 K2Aan_K03 K2Aan_K07	15	60	2		0,65	T/Z	Z	O			KO
2	W03-SM2001BH	Managerial course II	2					K2Aan_W11 K2Aan_K02 K2Aan_K03 K2Aan_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 Subjectgroup 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 Subjectgroup of courses	Way[3] of crediting	Subjectgroup 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-SM0003	Foreign language II		3				K2Aan_U07 K2Aan_U10 K2Aan_K01 K2Aan_K04	45	60	2		1,8	T/Z	Z	O		P	KO
2	SJO-SM0004	Foreign language I		1				K2Aan_U07 K2Aan_U10 K2Aan_K01 K2Aan_K04	15	30	1		0,6	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]
lec	cl	lab	pr	sem					
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 *(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 Subjectgroup of courses	Way[3] of crediting	Subjectgroup 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																	

4.2.2.2 *Physics* 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 Subjectgroup of courses	Way[3] of crediting	Subjectgroup 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																	

4.2.2.3 *Chemistry* block *(min. .... ECTS points):*

No.	Subject group of classes code	Name of Subjectgroup 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 Subjectgroup of courses	Way[3] of crediting	Subjectgroup 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

Altogether for general basics 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					

[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 the main field of study blocks

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

No.	Subject group of classes code	Name of Subjectgroup 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 Subjectgroup of courses	Way[3] of crediting	Subjectgroup 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	K2Aan_U08 K2Aan_U15 K2Aan_K01 K2Aan_K07	15	25	1	1	0,7	T/Z	Z		DN	P	K
2	W03W03-SM2054D	Graduate laboratory I			4			K2Aan_U03 K2Aan_U04 K2Aan_U09 K2Aan_K01 K2Aan_K05 K2Aan_K07	60	150	6	6	3	T	Z		DN	P	K
3	W03W03-SM2055D	Graduate laboratory II			14			K2Aan_U03 K2Aan_U04 K2Aan_U09 K2Aan_U10 K2Aan_U13 K2Aan_K01 K2Aan_K05 K2Aan_K07	210	500	20	20	9,5	T	Z		DN	P	K
4	W03W03-SM2056S	Graduation seminar					1	K2Aan_U05 K2Aan_U08 K2Aan_K01 K2Aan_K06 K2Aan_K07 K2Aan_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 Subjectgroup of courses	Way[3] of crediting	Subjectgroup 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	W03ANB-SM20BW	Elective course*	4					K2Aan_W16 K2Aan_K08	60	100	4		2,6	T/Z	Z				K
		Total	**4**						**60**	**100**	**4**		**2,6**						

List of elective course*

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 Subjectgroup of courses	Way[3] of crediting	Subjectgroup 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	W03ANB-SM2101w	Nonlinear optics for Chemists.	2						30	50	2		1,3	T/Z	Z				K
2	W03ANB-SM2102w	Biomaterials	2						30	50	2		1,3	T/Z	Z				K
3	W03ANB-SM2103w	Metallic materials	2						30	50	2		1,3	T/Z	Z				K
4	W03ANB-SM2104w	Basics molecular dynamics	2						30	50	2		1,3	T/Z	Z				K

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]
lec	cl	lab	pr	sem					
4		**18**		**2**	**360**	**825**	**33**	**29**	**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

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 W03W03-SM2054D W03W03-SM2055D 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 defence
seminar	e.g. participation in discussion, topic presentation, essay
diploma dissertation	prepared diploma dissertation

6. Range of diploma examination

1. Chemistry and physical chemistry of nano- and bio- materials
2. Methods of design of nano- and bio-materials
3. Engineering of nano- and bio-materials - selected issues

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: **ADVANCED NANO AND BIOMATERIALS - MONABIPHOT**

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

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

PROFILE: **general academic**

SPECIALIZATION: **----------**

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)
Field of study: Advanced Nano and Biomaterials-MONABIPHOT

Obligatory subjects
Optional subjects

Sem.	I	II	III
Godz.	25h / 30ECTS / 3E	25h / 30ECTS / 3E	23h / 30ECTS
26			
25	Fluorescence spectroscopy and bioimaging 2w + 1c (3 + 1 ECTS)	Elective courses 2w (2 ECTS)	
24			
23		Laser and microscopic techniques in materials analysis 2w (2 ECTS)	Elective courses 2w (2 ECTS)
22	Modern spectroscopy **E** 2w (2 ECTS)		
21		Nonlinear Optics for Chemists 1l (2 ECTS)	Advanced functional materials 6l (6 ECTS)
20	Biophotonics 1w + 2s (2 + 2 ECTS)	Nanoscale physics 2w + 1l (2+2 ECTS)	
19			
18			
17	Bioorganic chemistry **E** 2w (3 ECTS)	Nanomaterials **E** 2w + 1s (2 +1 ECTS)	
16			
15	Modern polymers 2w (2 ECTS)		Graduate laboratory II 14l (20 ECTS)
14		Organic electronics 1w + 1s (1+1 ECTS)	
13	Liquid crystals for photonics **E** 2w + 1l (3 + 1 ECTS)		
12		Advanced research methods in the engineering of materials **E** 2w + 1c + 1l (2 + 1 + 2 ECTS)	
11			
10	Mathematical methods in planning and analysis of experiment 2l (2 ECTS)		
9			
8	Managerial course II 2w (3 ECTS)	Advanced functional materials **E** 2w + 2s (2 + 2 ECTS)	
7			
6	Managerial course I 1w (2 ECTS)		
5	Foreign language II 3c (2 ECTS)		
4		Graduate laboratory I 4l (6 ECTS)	
3			
2	Foreign language I 1c (1 ECTS)		
1	Graduation proseminar 1s (1 ECTS)		Graduation seminar 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 21

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	W03ANB-SM2007L	Mathematical methods in planning and analysis of experiment			2			K2Aan_W05 K2Aan_W10 K2Aan_W17 K2Aan_U06 K2Aan_U08 K2Aan_U12	30	50	2		1,4	T	Z			P	PD
2	W03ANB-SM2006W	Liquid crystals for photonics	2					K2Aan_W03 K2Aan_W15	30	75	3	3	1,3	T/Z	**E**		DN		K
3	W03ANB-SM2006L	Liquid crystals for photonics.			1			K2Aan_W03 K2Aan_U04 K2Aan_U11 K2Aan_U14	15	25	1	1	0,7	T	Z		DN	P	K
4	W03ANB-SM2005W	Modern polymers	2					K2Aan_W01 K2Aan_W15 K2Aan_W18	30	50	2		1,3	T/Z	Z				K
5	W03ANB-SM2004W	Bioorganic chemistry	2					K2Aan_W13 K2Aan_W14 K2Aan_W15	30	75	3	3	1,3	T/Z	**E**		DN		K
6	W03ANB-SM2003W	Biophotonics	1					K2Aan_W07 K2Aan_W13	15	50	2		0,65	T/Z	Z				K
7	W03ANB-SM2003S	Biophotonics.					2	K2Aan_W07 K2Aan_U05 K2Aan_U06 K2Aan_U08	30	50	2		1,4	T/Z	Z			P	K

[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	W03ANB-SM2002W	Modern spectroscopy	2					K2Aan_W07 K2Aan_W08	30	50	2	2	1,3	T/Z	**E**		DN		PD
9	W03ANB-SM2001W	Fluorescence spectroscopy and bioimaging	2					K2Aan_W07 K2Aan_W13	30	75	3	3	1,3	T/Z	Z		DN		K
10	W03ANB-SM2001C	Fluorescence spectroscopy and bioimaging.		1				K2Aan_U12 K2Aan_U16 K2Aan_U17	15	25	1	1	0,7	T/Z	Z		DN	P	K
		Total	**11**	**1**	**3**		**2**		**255**	**525**	**21**	**13**	**11,35**		**3**			**6**	

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	W03-SM2002BH	Managerial course I	1					K2Aan_K02 K2Aan_K03 K2Aan_K07	15	60	2		0,65	T/Z	Z	O			KO
2	W03-SM2001BH	Managerial course II	2					K2aan_W11 K2Aan_K02 K2Aan_K03 K2Aan_K07	30	90	3		1,3	T/Z	Z	O			KO
3	SJO-SM0003	Foreign language II		3				K2Aan_U07 K2Aan_U10 K2Aan_K01 K2Aan_K04	45	60	2		1,8	T/Z	Z	O		P	KO
4	SJO-SM0004	Foreign language I		1				K2Aan_U07 K2Aan_U10 K2Aan_K01 K2Aan_K04	15	30	1		0,6	T/Z	Z	O		P	KO
5	W03W03-SM2053S	Graduation proseminar					1	K2Aan_U08 K2Aan_U15 K2Aan_K01 K2Aan_K07	15	25	1	1	0,7	T/Z	Z		DN	P	K
		Total	**3**	**4**			**1**		**120**	**265**	**9**	**1**	**5,05**					**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					
14	**5**	**3**		**3**	**375**	**790**	**30**	**14**	**16,4**

[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

Semester 2

Obligatory subjects / groups of classes Number of ECTS points 22

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	W03ANB-SM2014W	Advanced functional materials	2					K2Aan_W02 K2Aan_W04 K2Aan_W06 K2Aan_W12 K2Aan_W16 K2Aan_W18	30	50	2	2	1,3	T/Z	**E**		DN		K
2	W03ANB-SM2014S	Advanced functional materials.					2	K2Aan_W12 K2Aan_W15 K2Aan_U05 K2Aan_U06 K2Aan_U08 K2Aan_K07	30	50	2	2	1,4	T/Z	Z		DN	P	K
3	W03ANB-SM2013W	Advanced research methods in the engineering of materials	2					K2Aan_W07 K2Aan_W14	30	50	2	2	1,3	T/Z	**E**		DN		K
4	W03ANB-SM2013C	Advanced research methods in the engineering of materials		1				K2Aan_W14 K2Aan_U02 K2Aan_U11 K2Aan_K08	15	25	1	1	0,7	T/Z	Z		DN	P	K
5	W03ANB-SM2013L	Advanced research methods in the engineering of materials			1			K2Aan_W14 K2Aan_U02 K2Aan_U13 K2Aan_U16 K2Aan_K08	15	50	2	2	0,7	T	Z		DN	P	K
6	W03ANB-SM2012W	Organic electronics	1					K2Aan_W07 K2Aan_W13	15	25	1	1	0,65	T/Z	Z		DN		K
7	W03ANB-SM2012S	Organic electronics.					1	K2Aan_W13 K2Aan_W15 K2Aan_U05	15	25	1	1	0,7	T/Z	Z		DN	P	K

[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

								K2Aan_U06 K2Aan_U08										
8	W03ANB-SM2011W	Nanomaterials	2					K2Aan_W06 K2Aan_W13	30	50	2	2	1,3	T/Z	**E**		DN		K
9	W03ANB-SM2011S	Nanomaterials.					1	K2Aan_W13 K2Aan_W15 K2Aan_U05 K2Aan_U06 K2Aan_U08 K2Aan_K07	15	25	1	1	0,7	T/Z	Z		DN	P	K
10	W03ANB-SM2010W	Nanoscale physics	2					K2Aan_W04 K2Aan_W06 K2Aan_W12	30	50	2	2	1,3	T/Z	Z		DN		K
11	W03ANB-SM2010L	Nanoscale physics.			1			K2Aan_W12 K2Aan_U04 K2Aan_U09 K2Aan_U13 K2Aan_U16 K2Aan_K05	15	50	2	2	0,7	T	Z		DN	P	K
12	W03ANB-SM2009L	Nonlinear optics for Chemists.			1			K2Aan_W07 K2Aan_U04	15	50	2	2	0,7	T	Z		DN	P	K
13	W03ANB-SM2008W	Laser and microscopic techniques in materials analysis	2					K2Aan_W02 K2Aan_W04 K2Aan_W12 K2Aan_W15	30	50	2	2	1,3	T/Z	Z		DN		K
		Total	**11**	**1**	**3**		**4**		**285**	**550**	**22**	**22**	**12,75**					**11**	

[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	W03ANB-SM20BW	Elective course*	2					K2Aan_W16 K2Aan_K08	30	50	2		1,3	T/Z	Z				K
2	W03W03-SM2054D	Graduate laboratory I			4			K2Aan_U03 K2Aan_U04 K2Aan_U09 K2Aan_K01 K2Aan_K05 K2Aan_K07	60	150	6	6	3	T	Z		DN	P	K
		Total	**2**		**4**				**90**	**200**	**8**	**6**	**4,3**					**6**	

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					
13	**1**	**7**		**4**	**375**	**750**	**30**	**28**	**17,05**

[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

Obligatory subjects / groups of classes 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	W03ANB-SM2014L	Advanced functional materials..			6			K2Aan_W04 K2Aan_W12 K2Aan_U01 K2Aan_U04 K2Aan_U09 K2Aan_U10 K2Aan_U12 K2Aan_U13 K2Aan_U15 K2Aan_U16 K2Aan_U17	90	150	6	6	4,2	T	Z		DN	P	K
		Total			**6**				**90**	**150**	**6**	**6**	**4,2**					**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

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	W03ANB-SM20BW	Elective course*	2					K2Aan_W16 K2Aan_K08	30	50	2		1,3	T/Z	Z				K
2	W03W03-SM2055D	Graduate laboratory II			14			K2Aan_U03 K2Aan_U04 K2Aan_U09 K2Aan_U10 K2Aan_U13 K2Aan_K01 K2Aan_K05 K2Aan_K07	210	500	20	20	9,5	T	Z		DN	P	K
3	W03W03-SM2056S	Graduation seminar					1	K2Aan_U05 K2Aan_U08 K2Aan_K01 K2Aan_K06 K2Aan_K07 K2Aan_K08	15	50	2	2	0,7	T/Z	Z		DN	P	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					
2		**20**		**1**	**345**	**750**	**30**	**28**	**14,7**

[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
W03ANB-SM2006W	Liquid crystals for photonics	**1**
W03ANB-SM2004W	Bioorganic chemistry	
W03ANB-SM2002W	Modern spectroscopy	
W03ANB-SM2014W	Advanced functional materials	**2**
W03ANB-SM2013W	Advanced research methods in the engineering of materials	
W03ANB-SM2006W	Nanomaterials	

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 Materiały Funkcjonalne
Name of subject in English Advanced Functional Materials
Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2014W, W03ANB-SM2014L, W03ANB-SM2014S
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		90		30
Number of hours of total student workload (CNPS)	50		150		50
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		6		2
including number of ECTS points for practical classes (P)			6		2
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,3		4,2		1,4

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. General knowledge of mathematics, physics and chemistry

SUBJECT OBJECTIVES

C1 Extending knowledge about materials used in modern materials engineering.
C2 Acquisition of experience in independent development and presentation of the state of knowledge on the basis of scientific publications
C3 Getting to know measurement methods of advanced materials

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01 has general knowledge in the field of research carried out in modern material engineering
PEU_W02 has knowledge about the synthesis, properties and research of photorefractive materials
PEU_W03 has knowledge about the synthesis, properties and research of photochromic materials

PEU_W04 has knowledge about the synthesis, properties and research of thermo-, electro- and solvatochromes
PEU_W05 has knowledge about the production, properties and testing of organic and inorganic semiconductors
PEU_W06 has knowledge about the synthesis, properties and research of compounds based on coal
PEU_W07 has knowledge about the synthesis, properties and research of energy storage materials
PEU_W08 has knowledge about the production and testing of optical fibers and photonic crystals
PEU_W09 has knowledge about modern materials used in medicine
PEU_W10 has knowledge about the synthesis, properties and research of metamaterials
PEU_W11 has knowledge about the synthesis, properties and research of magnetic and ferroelectric materials
PEU_W12 has knowledge about the properties and research of superconductors
PEU_W13 has knowledge about the synthesis, properties and testing of porous materials
PEU_W14 has knowledge about the synthesis, properties and research of ceramic materials
PEU_W15 has knowledge about the synthesis, properties and studies of luminescent dyes

relating to skills:
PEU_U01 student is able to independently develop and present the state of knowledge on the basis of scientific publications
PEU_U02 student is able to independently perform material tests with advanced techniques
PEU_U03 student is able to analyze and interpret the obtained results

relating to social competences:
PEU_K01 The student can use scientific literature, accessing source materials and viewing them

PEU_K02 student is ready to critically evaluate his/her knowledge and received content

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Modern materials science	2
Lec 2	Photorefractive materials	2
Lec 3	Photochromic materials	2
Lec 4	Thermoplastic materials, electronic and solvatochromic	2
Lec 5	Organic and inorganic semiconductors	2
Lec 6	Carbon materials	2
Lec 7	Materials for energy storage	2
Lec 8	Fiber optics and photonic crystals	2
Lec 9	Materials in medicine	2
Lec 10	Metamaterials	2
Lec 11	Magnetic and ferroelectric materials	2

Lec 12	Superconductors	2
Lec 13	Porous materials	2
Lec 14	Ceramic materials	2
Lec 15	Luminescent dyes	2
	Total hours	30

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

Laboratory		**Number of hours**
Lab 1	BHP training. The way the laboratory is run. Locations and their discussion. Requirements for course credits.	6
Lab 2	The luminescent properties of organic dyes	6
Lab 3	Methods for determining the thickness of nanolayers	6
Lab 4	Nanomaterials - size effects	6
Lab 5	OFET - fabrication and characteristics	6
Lab 6	OLED - fabrication and characteristics	6
Lab 7	Characteristics of liquid crystals	6
Lab 8	Measurement of phototropic properties of liquid crystals	6
Lab 9	Two-dimensional thermo-optic analysis	6
Lab 10	Quantum efficiency, comparative method	6
Lab 11	Photochemical synthesis of nanostructured silver suspensions	6
Lab 12	Chemical synthesis of nanostructured gold suspensions	6
Lab 13	Fabrication of nanolayers	6
Lab 14	Repetition of the material	6
Lab 15	Repetition of the material, checking knowledge and passing the course	6
	Total hours	90

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

Seminar		Number of hours
Semin 1	Student presentations on topic Lec 1	2
Semin 2	Student presentations on topic Lec 2	2
Semin 3	Student presentations on topic Lec 3	2
Semin 4	Student presentations on topic Lec 4	2
Semin 5	Student presentations on topic Lec 5	2
Semin 6	Student presentations on topic Lec 6	2
Semin 7	Student presentations on topic Lec 7	2
Semin 8	Student presentations on topic Lec 8	2
Semin 9	Student presentations on topic Lec 9	2
Semin 10	Student presentations on topic Lec 10	2
Semin 11	Student presentations on topic Lec 11	2
Semin 12	Student presentations on topic Lec 12	2
Semin 13	Student presentations on topic Lec 13	2
Semin 14	Student presentations on topic Lec 14	2
Semin 15	Student presentations on topic Lec 15	2
	Total hours	30

TEACHING TOOLS USED
N1. Lecture with multimedia presentation and lecture using the board N2. Performing tasks in the laboratory N3. Problem discussion N4. The tests check (short essays) - used on laboratory N5. Reports from exercises laboratory

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 (laboratory)	PEU_U02	quizes

F2 (laboratory)	PEU_U03	reports
P (lecture)	PEU_W01 - PEU_W015	final exam
P (laboratory) = (F1+F2)/2		
P (seminar)	PEU_U01, PEU_U03, PEU_K01- PEU_K02	evaluation of multimedia presentation

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Original articles from Web of Science
[2] Internet source

SECONDARY LITERATURE:

[1] Internal instructions for individual laboratory classes

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

Prof. Jaroslaw Mysliwiec, jaroslaw.mysliwiec@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 metody badawcze w inżynierii materiałów*
Name of subject in English Advanced research methods in the engineering of materials
Main field of study (if applicable): *Chemistry and engineering of materials*
Specialization (if applicable): Advanced Nano and Biomaterials - MONABIPHOT
Profile: *academic*
Level and form of studies: *2nd level, full-time*
Kind of subject: *obligatory*
Subject code W03ANB-SM2013W, W03ANB-SM2013C, W03ANB-SM2013L
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	15	15		
Number of hours of total student workload (CNPS)	50	25	50		
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	1	2		
including number of ECTS points for practical classes (P)		1	2		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,3	0,7	0,7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge about the structure of the atom and chemical bonds.
2. Basic knowledge about the structure of popular engineering materials.
3. Basics of electrochemistry, the concept of electrochemical potential, the phenomenon of electrochemical corrosion.
4. Basics of the interaction of solids with different types of radiation. Principles of spectroscopic techniques.

SUBJECT OBJECTIVES

C1. Understanding the importance of solid surface in nanotechnology.
C2. To acquaint students with modern and advanced techniques of surface research, morphology and structure of engineering materials.
C3. Ability to choose an appropriate method of determining: surface composition, surface topography, adhesion and hardness to the material being tested.

C4. Understanding the interaction of the surface of the material with the corrosive environment.
C5. Ability to apply standards in making measurements and their statistical treatment.

SUBJECT EDUCATIONAL EFFECTS

related to knowledge:

PEU_W01 Student has elementary theoretical knowledge about XPS / AES methods and equipment working in ultra high vacuum.

PEU_W02 The student has a basic knowledge of the research possibilities of determining the surface chemical composition by XPS and AES.

PEU_W03 Student ma podstawową wiedzę o mikroskopii elektronowej (SEM) oraz mikroanalizie rentgenowskiej (EDS), a także o systemie orientacji i detekcji faz na podstawie dyfrakcji elektronów wstecznie rozproszonych (EBSD).

PEU_W04 The student has a basic knowledge of the method of determining the mechanical properties of materials based on the measurements of microhardness and adhesion, as well as on the method of determining geometric parameters of the surface.

PEU_W05 The student has a basic knowledge of the types of electrochemical corrosion and laboratory techniques for testing the corrosion resistance of materials. The student has a basic knowledge of electrochemical impedance spectroscopy (EIS).

PEU_W06 The student knows the basics of impedance spectroscopy to determine the material properties of dielectric materials.

PEU_W07 The student knows the basics of structural analysis by X-ray diffraction (XRD) in the analysis of metals, their alloys and ceramics.

related to skills:

PEU_U01 Student is able to characterize qualitatively and quantitatively the tested surface of a solid material.

PEU_U02 The student is able to perform basic operations on XPS spectra and use the XPS and AES databases for the purpose of qualitative interpretation of XPS, AES spectra.

PEU_U03 The student is able to select the parameters of the scanning microscope (SEM), microanalysis (EDS) and the EDS and EBSD databases that are appropriate for the material being studied.

PEU_U04 The student is able to perform a DC polarization measurement and is able to determine the basic electrical quantities that characterize the corrosion process.

PEU_U05 The student can perform the measurement using the EIS technique, analyze and interpret the simplest impedance spectrum, propose an electric substitute circuit.

PEU_U06 Student is able to determine the basic properties of dielectric material using impedance spectroscopy.

PEU_U07 The student can interpret the XRD diffractogram.

PEU_U08 Student based on available standards can interpret the type of damage of the coating during scratch-test adhesion measurements.

PEU_U09 The student is able to register the surface profile of the tested material and determine on its basis the most important geometric parameters of the tested surface.

PEU_U10 The student is able to measure the thickness of the coating / thin layer and interpret the dependence of the penetration depth on the applied force during microhardness measurement.

related to social competences:

PEU_K01 The student is ready to apply the acquired knowledge to solve research problems.

PEU_K02 The student understands the need to use expert knowledge when interpreting the obtained research results.

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	XPS, AES - basic concepts: surface, spectroscopic and X-ray notation. Photoelectric process - primary and secondary emission.	2
Lec 2	X-ray photoelectron spectroscopy (XPS / ESCA). “Depth” in XPS / AES analyzes. Spectrum and its components. Stages of the analytical process. Auger electron spectroscopy (AES). Basic instrumentation (UHV, energy analyzer, photon source, ion gun, manipulator).	2
Lec 3	Practical applications of electron spectroscopy in materials engineering. Examples of spectra (XPS / AES) and their interpretation: in microelectronics, ceramics, catalysis, semiconductor and polymer materials, metallurgy, and corrosion of materials.	2
Lec 4	Basic polarization techniques for testing the corrosion resistance of materials. Measuring systems. Interpretation of current-voltage characteristics.	2
Lec 5	Electrochemical impedance spectroscopy (EIS). Impedance and methods of its presentation, basic concepts, available measurement techniques, spectra and their analysis, electrical equivalent models in the study of corrosion processes.	2
Lec 6	The profilometric methods for determining the surface topography of coatings and thin films.	2
Lec7	Determining the thickness of coatings and thin layers. Available non-destructive measurement techniques.	2
Lec8	Determination of microhardness of coatings and layers.	2
Lec9	Determination of adhesion of coatings and layers.	2
Lec10	Impedance spectroscopy of dielectric materials.	2
Lec11	Basics of electron microscopy (SEM) and X-ray microanalysis (EDS). Basic instrumentation (electron and X-ray detectors, vacuum system, preparations used in electron microscopy).	2
Lec12	Application of SEM, EDS and EBSD in material engineering. Examples of SEM images, spectra and chemical composition of EDS and crystallographic orientation maps (EBSD). Basics of spectra interpretation.	2
Lec13	Application of SEM / PFIB and TEM techniques in the analysis of the structure of coatings and thin films. Sample preparation. Contemporary analytical capabilities.	2

Lec14	Structural investigations of metals and their alloys as well as ceramic materials by X-ray diffraction (XRD).	2
Lec15	The use of GC-MS in determination of organic compounds.	2
	Total hours	30

Classes		**Number of hours**
Cl 1	Organizational matters.	1
Cl 2	Data treatment and analysis of linear polarization resistance characteristics. Determination of electrochemical parameters from polarization curves.	2
Cl 3	Interpretation of impedance spectra from EIS measurements. Proposing of physical models and electric equivalent circuits. Calculation of the values of elements of the electric equivalent circuit by non-linear least squares method.	2
Cl 4	Familiarization with software for interpreting XPS and AES spectra on the basis of real experimental spectra. Electron spectra: qualitative and quantitative interpretations. Acquisition of low- and high-resolution spectra.	2
Cl 5	Identification of spectral components. Quantitative calculations of elemental surface composition. Elimination of spectral by-products, methods for determining the background line. Calibration of spectra.	2
Cl 6	Calculating the average mean free electron path (IMFP) based on available models. Calculating the thickness of passive / oxide layers based on selected models.	2
Cl 7	Determination of dielectric properties of ceramics by dielectric impedance spectroscopy. Spectra processing and interpretation.	2
Cl 8	GC-MS technique. Analysis of chromatograms for organic compounds.	2
	Total hours	15

Laboratory		**Number of hours**
Lab 1	Organizational matters. Health and safety training.	1
Lab 2	Determination of the corrosion rate using linear polarization resistance and polarization curves.	2
Lab 3	EIS spectroscopic measurements of the corrosion process of selected metals and alloys.	2
Lab 4	Measurement of surface roughness by contact profilometry method. Profile registration and determination of basic geometric parameters of the surface based on the standard.	2
Lab 5	Measurements of coating thickness by means of magnetic induction and Eddy current methods.	2
Lab 6	Measurements of microhardness of coatings and thin films. Oliver and Pharr method. Statistical analysis of results. Testing of adhesion and resistance to scratch of metal coatings using the scratch-test method. Microscopic evaluation of the scratch track based on the standard.	2
Lab 7	Analysis of the surface morphology of the material by means of scanning electron microscopy (SEM). Secondary electron and back scattered electron imaging.	2

Lab 8	Quantitative analysis based on X-ray microanalysis (EDS) as well as map analysis of crystallographic orientation (EBSD) of ceramics, metals and semiconductors.	2
	Total hours	15

TEACHING TOOLS USED

N1. Multimedia presentation - thematic lecture.
N2. Practical exercises in the laboratory.
N3. Presentation / demonstration.
N4. Computer.
N5. Use of available scientific literature (Web of Science, Scopus), NIST database.
N6. The use of SpecLab, XPSPeak, Quases, Gamry, Nova, SAI, CSM, Bruker, FEI, TEAM, Origin software.

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 = P1 (classes)	PEU_W01- PEU_W07, PEU_U01- PEU_U10, PEU_K01-K02	Grade from the tests
F1 (laboratory)	PEU_W01- PEU_W07, PEU_U01- PEU_U10, PEU_K01-K02	Grade from the reports
F2 (laboratory)	PEU_W01- PEU_W07, PEU_U01- PEU_U10, PEU_K01 -K02	Grade from the tests
P (laboratory) Arithmetic average of F1 and F2 forming grades		
P (lecture)	PEU_W01- PEU_W07	Final exam

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] XPSPeak41 Manual.
[2] An Introducing to Surface Analysis by XPS and AES; J.F. Watts, J. Wolstenholme, John Wiley&Sons Ltd., 2003.
[3] Electrochemical Impedance Spectroscopy; Mark E. Orazem, Bernard Tribollet, John Wiley & Sons Ltd., 2011.
[4] Scanning Electron Microscopy and X-Ray Microanalysis 4th ed., Goldstein, J.I., Newbury, D.E., Michael, J.R., Ritchie, N.W.M., Scott, J.H.J., Joy, D.C., 2018.
[5] K. Nitsch, Zastosowanie spektroskopii impedancyjnej w badaniach materiałów elektronicznych, Oficyna Wydawnicza PWr, 1999.
[6] B. D. Cullity and S. R. Stock, Elements of X-ray Diffraction, Pearson, 2001.

SECONDARY LITERATURE:

[1] http://www.casaxps.com/ebooks/ebooks.htm

[2] Oliver W.C., Pharr G.M. *„An improved technique for determining hardness and elastic modulus using load and displacement sensing indentation experiments”*. Journal of Materials Research. Vol. 7, No. 6 (1992): pp. 1564÷1583.
[3] https://www.gamry.com/application-notes/EIS/basics-of-electrochemical-impedance-spectroscopy/
[4] https://www.bruker.com/products/surface-and-dimensional-analysis/stylus-profilometers/dektak-xt/learn-more.html
[5] https://blog.phenom-world.com/
[6] https://www.ameteksi.com/products/materials-testing-systems/1296a-dielectric-interface
[7] https://www.fei.com/products/sem/quanta-sem/

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

DSc. Eng. Juliusz Winiarski, Assoc. Prof., juliusz.winiarski@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 **Chemia Bioorganiczna**
Name of subject in English **Bioorganic Chemistry**
Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level
Kind of subject: obligatory
Subject code W03ANB-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)	75				
Form of crediting (Examination)	x				
For group of courses mark (X) final course					
Number of ECTS points	3				
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. knowledge of the basics of organic chemistry and biochemistry
2. knowledge of the basics of chromatographic and spectroscopic methods
3. possession of practical skills related to the application of laboratory techniques of organic chemistry from the range of courses provided in the curriculum of the first-degree program
4. knowledge of the English language

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SUBJECT OBJECTIVES

C1. To familiarize students with the issues of bioorganic chemistry.
C2. To familiarize students with the issues of mimetics of biochemical processes.
C3. To acquaint students with the issues of molecular receptors.
C4. To familiarize students with the structure, properties and use of various groups of compounds used in bioorganic chemistry.
C5. To acquaint students with the practical possibilities of using particular groups of compounds as enzyme mimetics and molecular receptors.
C6, To acquaint students with the methods of obtaining macrocyclic receptors

C7. To acquaint students with scientific literature and literature examples

SUBJECT EDUCATIONAL EFFECTS

In terms of knowledge:

PEU_W01 - knows what is bioorganic chemistry and knows the scope of its application.

PEU_W02 - knows the properties of individual groups of compounds applicable in bioorganic chemistry

PEU_W03 - knows the application of discussed, individual groups of compounds in bioorganic chemistry

PEU_W04 - knows the basic methods of obtaining macromolecular compounds

PEU_W05 - knows the types of intermolecular interactions and which compounds participate in the formation of individual interactions

PEU_W06 - knows what supramolecular chemistry is, knows the different types and can give examples of the application of supramolecular complexes

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Presentation of the general characteristics of the subject	2
Lec 2	Mimetics of peptides and proteins	2
Lec 3	Mimetics of DNA and RNA nucleic acids	2
Lec 4	Structure, properties and applications of cyclodextrins	2
Lec 5	Structure, properties and application of dendrimers	2
Lec 6	Structure, properties and applications of calixarenes	2
Lec 7	Structure, properties and applications of cyclophanes	2
Lec 8	Structure, properties and applications of crown ethers and cyclic polyamines	2
Lec 9	Enzyme mimetics - molecular printing of polymers	2
Lec 10	Micellar catalysis, liposomes, fatty acid mimetics	2
Lec 11	Structure, properties and applications of porphyrins	2
Lec 12	Carbohydrates and their derivatives	2
Lec 13	Receptors for compounds having diol groups	2
Lec 14	Application of allotropic carbon groupings in bioorganic chemistry	2
Lec 15	Structure, properties and applications of rotaxanes and catenanes	2

	Total hours	30
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**
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. Informative and problem-oriented lecture using multimedia presentation N2. Consultation N3. Student's 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 - PEU_W06	Examination in oral form - presentation
F2		
F3		
P		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Jerry L. Atwood, Comprehensive Supramolecular Chemistry, Elsevier LTD 2017
[2] Marcel Van de Voorde, Nanoscience and Nanotechnology, De Gruyter 2018
[3] Czasopisma naukowe

Aktualne książki z zakresu chemii bioorganicznej, nanotechnologii i chemii supramolekularnej

SECONDARY LITERATURE:

Current books on bioorganic chemistry, nanotechnology and supramolecular chemistry

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

Piotr Młynarz, piotr.mlynarz@pwr.wroc.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 Biofotonika
Name of subject in English Biophotonics
Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2003W, W03ANB-SM2003S
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15	20	30		30
Number of hours of total student workload (CNPS)	30				30
Form of crediting (Examination / crediting with grade)	C				C
For group of courses mark (X) final course					
Number of ECTS points	2				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)	0,65				1,4

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. General chemistry
2. Basics of physics
3. Basics of biology at high school level

SUBJECT OBJECTIVES

C1 Obtaining additional knowledge in the field of synthesis, characterization and application of materials for biophotonics
C2 Knowledge about modern biophotonics
C3 Obtaining additional knowledge about materials used in biophotics
C4 To familiarize the student with modern biophotonics
C5 Knowledge about the development and limitations of biophotonics

SUBJECT EDUCATIONAL EFFECTS

In terms of knowledge:
Person who passed the subject:

PEU_W01 – Has structured, theoretically based general knowledge covering key issues in the field of biophotonics
PEU_W02 – Knows new methods of synthesizing materials for biophotonics
PEU_W03- Knows modern methods of material characterization for biophotonics
PEU_W04- Knows the basic methods of functionalization of materials for biophotonics
PEU_W05 - Understands and is able to explain descriptions in biophotonics
PEU_W06- Knows and understands selected applications of materials for biophotonics
PEU_W07- Knows and understands the prospects and threats related to the synthesis and application of materials for biophotonics
PEU_W08 – Knows modern methods of dynamic phototherapy
PEU_W09 – Has knowledge of the toxicity of nanobiomaterials
PEU_W10- Knows the applications of DNA in biophotics
PEU_W11 – Knows new methods of biosynthesis of nanomaterials
PEU_W12 – Knows popular biopolymers and their applications
PEU_W13 – Has knowledge about photonic biocrystals

In terms of skills:
Person who passed the subject:
PEU_U01 – Is able to name and define biophotics. Knows the latest literature on biophotonics. Searches for information in the field of biophotonics from available sources.
PEU_U02 - Knows modern imaging methods
PEU_U03- Is able to name and define advanced equipment used in biophotics
PEU_U04- Has language skills in the field of biophotonics.
PEU_U05- Is able to name and define biophotonic materials.
PEU_U06- Has language skills in the field of biophotonics.
PEU_U07- is able to critically analyze the prospects for the use of biophotonics
PEU_U08 - Is able to name and define new biomaterials
PEU_U09- Knows the latest literature on biophotonics
PEU_U10 – Knows various applications of photodynamic therapy
PEU_U11 – Can give an example of a biosensor
PEU_U12 – Knows biobased materials for photonics and materials engineering
PEU_U13 - Is able to define photonic biocrystals
PEU_U14 – Knows the 3-D printing technique for biomaterials

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	**Fundamentals of light-matter interactions.**	2
Lec 2	**Principles of Lasers, Current Laser Technology and Nonlinear Optics**	2
Lec 3	**Bioimaging – principles, techniques and applications**	2
Lec 4	**Principles of biosensors**	2
Lec 5	**Plasmonic nanoparticles for cancer detection and treatment**	2
Lec 6	**Light activated therapy – photodynamic therapy**	2
Lec 7	**Photonics biocrystals**	2

Lec8	**Biocompatible materials for photonics – 3-D printing of new biomaterials.**	1

Seminar		**Number of hours**
Semin 1	**Bioimaging**	2
Semin 2	**Bioimaging in therapies**	2
Semin 3	**Biosensors**	2
Semin 4	**Biosensors in practice**	2
Semin 5	**Plasmonic nanoparticles for cancer detection and treatment**	4
Semin 6	**Photodynamic therapy**	2
Semin 7	**Antibacterial photodynamic therpy**	2
Semin 8	**Photonics crystals in nature**	4
Semin 9	**Advances in 3-D printing for medicine**	4
Semin 10	**Biomaterials for photonics**	4
Semin 11	**Nonlinear bioimaging**	2
	Total hours	30

TEACHING TOOLS USED
N1. N1 Multimedia lectures N2 Workshop seminars N3 Own work – preparation of a presentation/paper N2. N3.

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-W1 to W13	Presentation /lecture
F1 (wykład)		
F1 = P1 (seminarium)	PEU-W1 do W13, PEU-U1 do U14	Presentation

P

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] [1] M. Jurgen, T. Mayerh€ofer, and J Popp Handbook of biophotonics, Wiley 2013

SECONDARY LITERATURE:

[1] Paras N. Prasad, Nanophotonics, Wiley-Interscience, 2004
[2] Paras N. Prasad, Introduction to Biophotonics, 2004
[3] Challa Kumar, Nanomaterials for Medical Diagnosis and Therapy, Wiley, 2007
[4] Yoon Yeo, Nanoparticulate drug delivery systems : strategies, technologies, and applications, Wiley, 2013

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

Katarzyna Matczyszyn Katarzyna.matczyszyn@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 Spektroskopia fluorescencyjna i bioobrazowanie
Name of subject in English Fluorescence spectroscopy and bioimaging
Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2001W, W03ANB-SM2001C
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	15			
Number of hours of total student workload (CNPS)	75	25			
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	3	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)	1,3	0,7			

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. General knowledge about biochemistry and chemistry
2. Skills in basic chemistry/biochemistry calculations

SUBJECT OBJECTIVES

C1 To provide an advanced understanding of the core principles and selected topics of biological chemistry and their experimental basis
C2 To enable students to acquire knowledge and understanding of selected aspects of fluorescence spectroscopy and bio-imaging in context of proteins visualization. This will be pursued by means of lecture series and wet laboratory classes.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 student knows the principles of chemical biology, cancer biology, and the role of proteolytic enzymes in health and disease

PEU_W02 student knows modern technologies for the proteins visualization in biological samples with emphasis on the detection of proteolytic enzymes using activity based probes

PEU_W03 student knows and understands the principles of the spectrofluorometric plate readers, confocal microscopy and mass cytometry

relating to skills:

PEU_U01 student can apply the principles of various biochemical techniques to visualize proteins in biological samples using spectrofluorimeter, LC-MS, fluorescence microscopy, infrared bio-imaging system and mass cytometry

PEU_U02 student is able to analyze and critically evaluate the results obtained by using aforementioned techniques and systems

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Basis of biological chemistry	2
Lec 2	Introduction to cell and molecular biology	2
Lec 3	Introduction to proteomics	2
Lec 4	Biochemical techniques in life sciences	2
Lec 5	Proteomic techniques in life sciences	2
Lec 6	Lifestyle diseases: the biology of cancer	2
Lec 7	Lifestyle diseases: the biology of diabetes	2
Lec 8	Proteomic techniques for the visualization of enzymes activtiy	2
Lec 9	Fluorescent techniques for the visualization of enzymes activtiy	2
Lec 10	Fluorescence microscopy as a tool for proteins visualization	2
Lec 11	Flow cytometry as a tool for diseases diagnosis	2
Lec 12	The principles of mass cytometry	2
Lec 13	The principles of imaging mass cytometry (IMC)	2
Lec 14	The application of mass cytometry and IMC for multiparametric bio-imaging	2
Lec 15	Final exam	2
	Total hours	30

	Classes	**Number of hours**
Cl 1	Introduction to enzyme kinetics (principles, methods, calculations)	2
Cl 2	Introduction to proteomics (principles, methods, calculations)	2
Cl 3	Detection of peptides hydrolysis by mass spectrometry techniques	2

Cl 4	Detection of enzymes activity with chemical probes and proteomics	2
C1 5	Detection of enzymes activity with fluorescent probes and antibodies	2
C1 6	Application of mass spectrometry in clinical proteomics	2
C1 7	Application of mass cytometry in clinical proteomics	2
C1 8	Final remarks	1
	Total hours	15

Laboratory		**Number of hours**
Lab 1		
Lab 2		
Lab 3		
Lab 4		
Lab 5		
…		
	Total hours	

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. PowerPoint presentations (for lectures and classes)
N2. Scientific literature
N3. Data generated from experiments performed on spectrofluorimeters, fluorescence scanners, confocal microscopes, mass cytometers and imaging mass cytometers
N4. Other teaching tools will include: laboratory demonstrations, guest lecturers, online simulations, case studies and group projects.

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 (for lecure)	PEU_W01-W03	test
F1 (for classes)	PEU_U01-U02	Students' activtiy during classes
F2 (for classes)	PEU_U01-U02	The quality of group project and other tasks

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] **Principles and Techniques of Biochemistry and Molecular Biology**, by Keith Wilson and John Walker, *Cambridge University Press*

[2] **Principles of Fluorescence Spectroscopy,** by Joseph R. Lakowicz, *Springer*

[3] **Proteomics: Principles, Techniques, and Analysis** Syrawood Publishin House, Peter Wyatt

[4] High-Dimensional Single Cell Analysis: Mass Cytometry, Multi-parametric Flow Cytometry and Bioinformatic Techniques, by Harris G. Fienberg and Garry P. Nolan, *Springer*

SECONDARY LITERATURE:

[1] **Biochemistry: The Chemical Reactions of Living Cells**, by David Metzler, *Elsevier*

[2] **Introduction to Cancer Biology** by Robin Hesketh, *Cambridge University Press*

[3] **Handbook of Proteolytic Enzymes,** by Neil D. Rawlings and Guy S. Salvesen, *Elsevier*

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

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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 Techniki laserowe i mikroskopowe
Name of subject in English Laser and microscopy techniques
Main field of study (if applicable): Advanced Nano and Biomaterials MONABIPHOT
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2008W
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)					
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. Basics of physics
2. Basics of spectroscopy
3. Basics of chemistry
4. Basics of biology

SUBJECT OBJECTIVES

C1 Knowledge of basic issues in the field of microscopy
C2 To familiarize the student with modern microscopic techniques
C3 Teaching the selection of appropriate microscopic techniques for specific materials

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01 – Knows the basics of optical microscopy
PEU_W02 – Knows fluorescence microscopy methods

PEU_W03- Knows fluorescence lifetime microscopy methods
PEU_W04- Knows multiphoton microscopy methods
PEU_W05- Knows the basics of electron microscopy
PEU_W06- Knows scanning probe microscopy techniques (AFM, STM)
PEU_W07- Knows near-field microscopy techniques
PEU_W08 - Knows the latest microscopic methods of imaging below the diffraction limit

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec 1	Basics of light microscopy (basic elements of microscope, concept of microscope resolution, bright field, dark field, polarizing microscopy, etc.)	2
Lec 2	Basic concepts of fluorescence and confocal microscopy (fluorescence microscopy, autofluorescence, fluorescent labels, confocal microscopy)	2
Lec 3	Fluorescence microscopy methods and lifetime microscopy (FRAP, FRET, TIRF, FLIM techniques)	2
Lec 4	Multiphoton microscopy (multiphoton fluorescence, second and third harmonic generation (SHG, THG), microscopy	2
Lec 5	Electron microscopy (scanning electron microscopy SEM, transmission electron microscopy TEM)	2
Lec 6	Atomic force microscopy and other microscopic techniques with a scanning probe (AFM atomic force microscope, STM scanning tunneling microscope)	2
Lec 7	Near-field microscopy (NSOM scanning near-field microscopy methods)	2
Lec 8	Electron microscopy in practice	2
Lec 9	Scanning microscopy in practice	2
Lec 10	Super-resolution microscopy methods (STED, GSD techniques, STORM statistical microscopy, PALM)	2
Lec 11	Atomic force microscopy in practice	2
Lec 12	Practical examples of microscopy applications and techniques	2
Lec 13	Practical examples of microscopy applications and techniques	2
Lec 14	Practical examples of microscopy applications and techniques	2
Lec 15	Final evaluation of the work	2
	Total hours	30

TEACHING TOOLS USED
N1. Multimedia lectures N2. Own work - independent studies and preparation of a report/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

F1	PEU_W01-08	Colloquium
F2	PEU_W01-08	Evaluation of the report/speech
P=(F1+F2)/2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Peter W. Hawkes, John C. H. Spence "Handbook of Microscopy" Springer, 2019
[2] A. Barbacki i in. „Mikroskopia elektronowa" Wydawnictwo Politechniki Poznańskiej, 2007
[3] M. Kopaczyńska „Mikroskopia sił atomowych (AFM) - biomedyczne zastosowanie pomiarów w nanoskali" Oficyna Wydawnicza Politechniki Wrocławskiej, 2010
[4] http://www.microscopyu.com/
[5] http://zeiss-campus.magnet.fsu.edu/

SECONDARY LITERATURE:

[1] M. Sauer, J. Hofkens, J. Enderlein "Handbook of fluorescence spectroscopy and imaging: from single molecules to ensembles." Wiley 2011
[2] H. Tanke, B. Herman, "Fluorescence Microscopy" Taylor & Francis Group, 2006
[3] B. R. Masters, P. T. C. So "Handbook of Biomedical Nonlinear Optical Microscopy" Oxford University Press 2008
[4] P. Eaton, P. West "Atomic force microscopy", Oxford University Press, 2011
[5] C. J. Chen "Introduction to scanning tunneling microscopy" Oxford University Press 2008
[6] L. Novotny, B. Hecht "Principles of Nano-Optics" Cambridge University Press 2012

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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 Ciekłe kryształy dla fotoniki
Name of subject in English LIQUID CRYSTALS for PHOTONICS
Main field of study (if applicable): Advanced Nano and Biomaterials MONABIPHOT
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2006W, W03ANB-SM2006L

Group of courses No

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		15		
Number of hours of total student workload (CNPS)	75		50		
Form of crediting (Examination / crediting with grade)	egzamin		Crediting with grade		
For group of courses mark (X) final course					
Number of ECTS points	3		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)	1,3		0,7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. General physics,
2. General chemistry

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SUBJECT OBJECTIVES

C1 To provide students with a general knowledge of chemical structure, interactions and physics of liquid crystals.
C2 To provide students with a knowledge about physicochemical properties of various mesophases: nematics, smectics, and chiral nematics including chiral ferroelectric LCs.
C3 To provide students with deep understanding of LCs optics
C4 To provide students with a knowledge related to applications of liquid crystals in display technologies, optical filtering, spatial light modulators.

C5 To provide students with contemporary photonic devices based on liquid crystals.

SUBJECT EDUCATIONAL EFFECTS

PEU_W01 - Student knows the principles of classification of liquid crystals in view of their structure, symmetry, origin of mesophase and macroscopic organization in bulk.

PEU_W02 - Student understands the liquid crystallinity and physical consequences of this state

PEU_W03 – Student understands in depth optical and dielectric properties of liquid crystals

PEU_W04 – Student knows and is able to identify various mesophases used for different functions like information displaying, processing and dynamic storage.

PEU_W05 - Student understands the advanced technologies of liquid crystal panels fabrication. He knows and understands the functioning of LC in photonics and knows the advantages and limits of these materials.

related to skills:

PEU_U01 – Student is able to make LC panels and characterize their optical properties.

PROGRAMME CONTENT

Lectures		**Number of hours**
Lec 1	Brief introduction to liquid crystalline state. Calamitic and discotic liquid crystals and its chemical structures. Polymorphism. Thermotropic liquid crystals.	2
Lec 2	Systematics of liquid crystals: nematics and smectics, cholesterics and their main properties.	2
Lec 3	Physicochemical properties of liquid crystals. Sequence of phases, phase transitions, textures, defects, viscosity.	2
Lec 4	Order parameter and anisotropy of electric and magnetic susceptibilities, Interaction of LC with electric field, Freedericksz effect, elastic constants K_{11}, K_{22} and K_{33}.	2
Lec 5	Dielectric, optic, elastic, hydrodynamic and thermal methods used for characterization of LCs in their various phases. Polarizing light studies of LCs.	2
Lec 6	Optical properties of liquid crystals. Refractive indices, birefringence, light scattering and light propagation, molecular dichroism).	2

Lec 7	The most important applications of liquid crystals and polymeric liquid crystals - liquid crystal displays and spatial light modulators.	2
Lec 8	Structure and properties of lyotropic liquid crystals. Kraft's plot. Amphiphilic molecules, micelles, mono- and bilayers, biological membranes.	2
Lec 9	Molecular engineering of LCs. Ferroelectric, ferrielectric and antiferroelectric LCs. Blue phases in LCs.	2
Lec 10	Polymeric liquid crystals, polymer dispersed liquid crystals and their applications.	2
Lec 11	Introduction of models of nematic LC description. Phenomenological approach. Free energy and theory of Maier and Saupe.	2
Lec 12	Optical properties of LCs. Mie light scattering.	2
Lec 13	Nonlinear optical phenomena in liquid crystals. Mechanism of giant optical nonlinearity. Laser induced molecular reorientations. Laser-induced dye-assisted molecular reorientations (Janossy effect).	2
Lec 14	Second harmonic generation, stationary degenerate wave mixing, optical phase conjugation, self-modulations effects, soliton formation, light amplification and optical limiting.	2
Lec 15	Review of applications of LCs in display technology and spatial light modulators. Electrically addressed spatial light modulators (SLM) for telecommunications. Real-time holography and use of SLM for optical manipulation of nanoscopic objects "optical tweezers". Tuning of liquid crystals in waveguides and photonic crystals.	2
	Total hours	30

Laboratory		**Number of hours**
Lab 1	Preparation of the LC panel	5
Lab 2	Microscopic studies of LC samples	5
Lab 3	Thermal evaluation of LC samples	5
	Total hours	15

TEACHING TOOLS USED
N1. Lecture with use of multimedia presentation. N2. Lecture with elements of discussion of problems

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 (lecture)	PEU_W01 PEU_W02 PEU_W03 PEU_W04 PEU_W05	Written test. Evaluation of test max. 100 pts 3.0 if 50-60 % pts 3.5 if 61-70 % pts 4.0 if 71-80 % pts 4.5 if 81-90% pts 5.0 if 91-95% pts 5.5 if 96-100 % pts
P1 (laboratory)	PEU_U01	Evaluation of a single report of performed measurements

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Displeje ciekłokrystaliczne – fizyka, technologia, zastosowanie, PWN, Warszawa (1993)
[2] Handbook of Liquid Crystals, D. Demus, J. Goodby, G.W. Gray, H.W. Dpiess, V. Vill, vols. 1-3, Wiely-VCH (1998)
[3] I.C. Khoo, Liquid Crystals, Physical Properties and Nonlinear optical Phenomena, J. Wiley, New York (1995)
[4] L.M. Blinov, V.G. Chigrinov, Electrooptic Effects in Liquid Crystal Materials, Springer (1996)
[5] P. Yeh, C. Gu, Optics of Liquid Crystals, Wiley Intersicence Publication, J. Wiley and Sons, New York (1999)

SECONDARY LITERATURE:

[1] Original scientific articles available through electronic literature database of Main Library of WUST
[2] Materials Today - scientific journal

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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 METODY MATEMATYCZNE W PLANOWANIU I ANALIZIE EKSPERYMENTU

Name of subject in English MATHEMATICAL METHODS IN PLANNING AND ANALYSIS OF EXPERIMENT

Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT

Specialization (if applicable):

Profile: academic

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

Kind of subject: obligatory

Subject code W03ANB-SM2007L

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)			60		
Form of crediting (Examination / 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)			1,4		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. General physics
2. General chemistry

SUBJECT OBJECTIVES

C1 The aim of the subject is to familiarize students with the experimental data analysis
C2 Familiarizing the student with the methods of data analysis
C3 Acquiring the ability to carry out the data analysis process

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 Has basic knowledge of selecting and fitting a mathematical model to experimental data.

PEU_W02 Obtains knowledge about authorized inference methods.

PEU_W03 Has knowledge of the chemical and physical characteristics of materials and their impact on their functional properties

relating to skills:

PEU_U01 Is able to calculate the electrical, optical, magnetic and mechanical properties of polymers using a computer program.

PEU_U02 Is able to conduct literature research on a specific scientific and research problem. Has basic skills in planning and conducting scientific research.

PEU_U03 Is able to conduct scientific experiments, develop and interpret their results and relate them to appropriate theories or scientific hypotheses. Is able to determine directions for further learning and implement the self-education process. Is able to apply the principles of safe work in a chemical laboratory.

PROGRAMME CONTENT

	Laboratory	**Number of hours**
Lab 1	Planning experiments	2
Lab 2	Selection of experimental methods	2
Lab 3	Computer data analysis - Origin, ImageJ	2
Lab 4	Computer data analysis - Python	2
Lab 5	Descriptive statistics	2
Lab 6	Statistical hypotheses	2
Lab 7	The use of a statistical description	2
Lab 8	Integral methods	2
Lab 9	Differential methods	2
Lab 10	Signal filtration	2
Lab 11	Image analysis - part 1	2
Lab 12	Image analysis - part 2	2
Lab 13	Image analysis - part 3	2
Lab 14	Review of experimental methods	2
Lab 15	Review of experimental methods	2
	Sum of hours	30

TEACHING TOOLS USED

N1. Performing tasks in the laboratory
N2. Computer / computer program / programming

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)		
P	PEU_W01-W03, PEU_U01-U03	Project evaluation from analysis of experimental data

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Alistair Croll, Benjamin Yoskovitz, „Lean Analytics: Use Data to Build a Better Startup Faster", "O'Reilly Media, Inc.", 2013

[2] Viktor Mayer-Schönberger, "Big Data : a Revolution that Will Transform how We Live, Work, and Think", Mariner Books, Houghton Mifflin Harcourt, 2013

[3] Wes McKinney, "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Ipython", O'Reilly Media, Incorporated, 2017

SECONDARY LITERATURE:

[1] Original scientific articles available through electronic literature database of Main Library of WUST

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

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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 polimery
Name of subject in English Modern polymers
Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2005W

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)	1,3				

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.Basic knowledge of organic chemistry
2.Basic knowledge of either polymer chemistry or material science

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SUBJECT OBJECTIVES

C1 To provide students with basic knowledge of polymers structure.
C2 To provide students with knowledge of main polymerization mechanisms and techniques as well as chosen methods of chemical modification of macromolecules.
C3 To acquaint students with the most important groups of modern polymers and methods of their fabrication

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 student knows the principles of polymer syntheses, relationships between type of polymerization and properties of the final product

PEU_W02 student knows the methods of polymer modification and knows how to give the desired properties to the polymers

…

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Program of lecture – basic polymers' features, differences from low molecular compounds, definitions.	2
Lec 2	Methods of polymer syntheses – relationship between polymerization and properties of final product	2
Lec 3	Suspension polymerization and modification of polymers' morphology; introduction of polymers to modern organic and analytical chemistry; Solid Phase Synthesis (SPS)	2
Lec 4	Chemical modifications leading to polymeric scavengers and carriers for catalysts	2
Lec 5	Syntheses of High Internal Phase Polymers and related multi-phase polymeric materials	2
Lec 6	Obtaining of thermosensitive polymers displaying Lower Critical Solubility Temperature (properties and applications)	2
Lec 7	Fabrication of semi-synthetic materials. Bio-based polymers revisited (a return to Nature)	2
Lec 8	Polymeric carriers for enzymes	2
Lec 9	Hydrogels syntheses and modifications. and their applications	2
Lec 10	Other methods of polymers' synthesis - plasma modification – superhydrophobic polymers	2
Lec 11	Making of 'smart" fibrous polymers – modern superhydrophobic, modern conducting materials. Electrospinning of multifunctional composite fibers	2
Lec 12	Making of conducting polymers - electropolymerization (poly(acetylenes), poli(pyrroles), poly (tiophenes)	2
Lec 13	Ionic polymers – ionophores; ion-exchangers and their synthesis, modern ion-exchangers and coordinating resins	2
Lec 14	Polymeric analogues of Ionic Liquids – synthesis and applications	2
Lec 15	Synthesis of self-healing polymers	2
	Total hours	30

	Classes	**Number of hours**
Cl 1		
Cl 2		
Cl 3		
Cl 4		
..		

	Total hours	
Laboratory		**Number of hours**
Lab 1		
Lab 2		
Lab 3		
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. PowerPoint presentations N2. Scientific literature (is also included on each subject slide)

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=P	PEU_W01-W02	test

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] M. Chanda, S.K. Roy, "Industrial Polymers, Specialty Polymers, and Their Applications", Boca Raton etc., CRC Press/Taylor & Francis Group, 2009.
[2] F. Mohammad (Ed), "Specialty Polymers: Materials And Applications", I. K. International Pvt Ltd, Anshan Ltd, Tunbridge Wells, 2007.
[3] papers from the scientific journals provided by the lecturer

SECONDARY LITERATURE:

[1] R. Barbucci (Ed.), "Hydrogels. Biological Properties and Applications", Springer-Verlag Italia, Milan 2009.
[2] R.M. Ottenbrite, K. Park, T. Okano (Eds.), "Biomedical Applications of Hydrogels Handbook", Springer Science & Business Media New York, 2010.

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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 ……Zaawansowana spektroskopia…….
Name of subject in English ……Modern Spectroscopy…….
Main field of study (if applicable): …Chemistry…….
Specialization (if applicable): …… Advanced Nano and Biomaterials - MONABIPHOT
Profile: academic ~~/ practical~~*
Level and form of studies: - 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2002W
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)					
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. General chemistry
2. Fundamentals of physics
3. Fundamentals of physical chemistry

SUBJECT OBJECTIVES

C1 To provide students with a general knowledge on the modern spectroscopy
C2 To provide students with a knowledge on spectroscopic setups and techniques
C3 To provide students with a trends in materials characterization using spectroscopic techniques

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
P7U_W01student knows the basic definitions of spectroscopy, especially optical spectroscopy
P7U_W02 student knows the light sources applied in spectroscopy
P7U_W03 student knows the modern setups applied in spectroscopic measurements

P7U_W04 student knows the time-resolved spectroscopies and techniques such as TCSPC
P7U_W05 student knows advanced time-resolved spectroscopies and techniques such as pump-probe
P7U_W06 student knows the selected aspects of nonlinear optical spectroscopy
P7U_W07 student knows the spectroscopic techniques such as Hyper-Rayleigh
P7U_W08 student knows the Hyper-Raman spectroscopy
P7U_W09 student knows the infrared spectroscopies
P7U_W10 student knows new techniques such as CARS and SERS
P7U_W11 student knows techniques of Raman and IR microspectroscopy
P7U_W12 student knows techniques of chiral materials investigations
P7U_W13 student knows new modulation spectroscopy techniques
P7U_W14 student knows new trends in spectroscopy

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	**Introduction to modern spectroscopy.** Definitions.	2
Lec 2	**Light sources in laser spectroscopy.**	2
Lec 3	**Modern spectroscopy setups.**	2
Lec 4	**Time-resolved techniques part 1.** Techniques like TCSPC.	2
Lec 5	**Time-resolved techniques part 2.** Techniques like pump-probe.	2
Lec 6	**Nonlinear spectroscopy part 1.** Multiphoton absorption**,** z-scan technique, saturable absorption spectroscopy.	2
Lec 7	**Nonlinear spectroscopy part 2.** Hyper-Rayleigh spectroscopy.	2
Lec 8	**Nonlinear spectroscopy part 3.** Hyper-Raman spectroscopy.	2
Lec 9	**Modern infra-red spectroscopy.** Ultrafast spectroscopy, 2D-IR	2
Lec 10	**Raman scattering spectroscopy**. Resonant spectroscopy, micro-Raman, SERS, CARS	2
Lec 11	**Raman and IR imaging techniques.**	2
Lec 12	**Chiral spectroscopy – circular dichroism.**	2
Lec 13	**Modulation spectroscopy.** Examples of light-, magnetic field, electric field stimulated spectroscopies.	2
Lec 14	**New trends in modern spectroscopy.**	2
Lec 15	**Colloquium**	2

TEACHING TOOLS USED

N1. Multimedia presentation
N2. Discussions during the lectures

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	P7U_W1-W14	test

PRIMARY LITERATURE:

[1] H.Abramczyk, Spektroskopia laserowa, skrypt PWr, 2011

[2] W. Demtröder, Spektroskopia laserowa. Wydawn. Naukowe PWN, 1993

ADDITIONAL LITERATURE:

[3] A. Corney, Atomic and laser spectroscopy. Oxford Classic Texts in the Physical Sciences, 2006

[4] S. Svanberg, Atomic and Molecular Spectroscopy. Springer, 2004

[5] J.M. Hollas, Modern Spectroscopy, 2004

[6] Joseph R. Lakowicz, Principles of Fluorescence Spectroscopy , Springer, 2006

[7] Max Diem, Introduction to Modern Vibrational Spectroscopy Wiley, 1993

Michael D. Fayer ed., Ultrafast Infrared Vibrational Spectroscopy, CRC press 2013.

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

Prof. Marek Samoć marek.samoc@pwr.edu.pl, Dr hab. inż. Katarzyna Matczyszyn, prof. PWr katarzyna.matczyszyn@pwr.edu.pl, Dr inż. Joanna Olesiak-Bańska joanna.olesiak@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 Nanomateriały
Name of subject in English Nanomaterials
Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2011W, W03ANB-SM2011S
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				15
Number of hours of total student workload (CNPS)	50				25
Form of crediting (Examination / crediting with grade)					
For group of courses mark (X) final course					
Number of ECTS points	2				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)	1,3				0,7

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. General chemistry
2. Basics of physics
3. Basics of biology

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SUBJECT OBJECTIVES

C1 To provide students with a general knowledge on the synthesis of nanomaterials
C2 To provide students with a general knowledge on the chemical and physical properties of nanomaterials
C3 To provide students with a general knowledge on the applications of nanomaterials
C4 To provide students with a general knowledge on the challenges and dangers of the applications of nanomaterials

SUBJECT EDUCATIONAL EFFECTS

related to knowledge:
PEU_W01student knows the differences in the properties of nanomaterials and bulk materials

PEU_W02 student knows the methods of the synthesis of nanomaterials
PEU_W03 student knows the lithographic techniques used to produce nanomaterials
PEU_W04 student knows methods of characterization of nanomaterials – structural investigations and optical spectroscopies and microscopies of a single nanoparticle, nanomanipulation
PEU_W05 student knows the properties and applications of plasmonic nanomaterials
PEU_W06 student knows the properties and applications of metal nanoparticles
PEU_W07 student knows the properties and applications of quantum dots
PEU_W08 student knows the properties and applications of carbon nanomaterials
PEU_W09 student knows the properties and applications of lanthanide-doped nanomaterials
PEU_W10 student knows the properties and applications of 2D nanomaterials
PEU_W11 student knows the properties and applications of nanofibers and composite nanomaterials
PEU_W12 student knows the processes in self-assembly of nanomaterials
PEU_W13 student knows the methods of bioconjugation and functionalization of nanomaterials
PEU_W14 student knows and understands the dangers of the applications of nanomaterials

related to skills:
PEU_U01 - Can name and define concepts in the field of nanomaterials and search for information on nanomaterials from available sources.
PEU_U02- Can name methods of synthesis of colloidal nanomaterials.
PEU_U03- Can name and compare the physical methods of synthesis of nanomaterials.
PEU_U04- Has language skills in the field of nanoparticle characterization methods.
PEU_U05- Is able to recognize, name and define plasmonic nanomaterials
PEU_U06- Is able to recognize, name and define metal nanoparticles
PEU_U07- Can recognize, name and define properties and applications of quantum dots
PEU_U08- Is able to recognize, name and define properties and applications of carbon nanomaterials
PEU_U09- Can recognize, name and define properties and applications of 2D nanomaterials
PEU_U10 - Is able to recognize, name and define properties and applications of nanoparticles with lanthanides
PEU_U11 - Is able to recognize, name and define properties and applications of nanofibers and nanocomposites
PEU_U12 - Can name and define methods for self-assembly of nanoparticles
PEU_U13 - Can name methods of nanoparticles functionalization
PEU_U14 - Can identify the dangers and prospects of nanomaterials applications

related to social competences:
PEU_K01 student is ready to critically evaluate his/her knowledge and received content

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Introduction to nanomaterials, definitions, nanomaterials vs. bulk materials, general methods of nanomaterials preparation	2
Lec 2	Synthesis of nanomaterials, colloidal nanoparticles	2
Lec 3	Physical techniques for nanomaterials preparation	2

Lec 4	Characterization of nanomaterials – structural investigations and optical spectroscopies and microscopies of a single nanoparticle	2
Lec 5	Plasmonic nanoparticles: synthesis, properties and applications	2
Lec 6	Metal nanoparticles: nanoclusters, heterostructures	2
Lec 7	Quantum dots: synthesis, properties, applications	2
Lec 8	Carbon nanomaterials: synthesis, properties, applications	2
Lec 9	2D nanomaterials (TMD, graphene etc.)	2
Lec 10	Lanthanide-doped nanomaterials: synthesis, properties, applications	2
Lec 11	Biology-inspired nanomaterials	2
Lec 12	Self-assembly of nanoparticles	2
Lec 13	Functionalization of nanomaterials, bioconjugation	2
Lec 14	Perspectives, challenges and dangers in the applications of nanomaterials. Nanotoxicology.	2
Lec 15	Exam	2
	Total hours	30

Seminar		**Number of hours**
Semin 1	Introduction to presentation of nanomaterials and recent discoveries in nanotechnology	2
Semin 2	Presentations of students on nanomaterials	2
Semin 3	Presentations of students on nanomaterials	2
Semin 4	Presentations of students on nanomaterials	2
Semin 5	Presentations of students on nanomaterials	2
Semin 6	Presentations of students on nanomaterials	2
Semin 7	Evaluation	1
	Total hours	15

TEACHING TOOLS USED
N1. Multimedia presentation N2. Discussion during lectures and seminars

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 (lecture)	PEU W01-14	exam
P2 (seminar)	PEU U01-14	student presentation

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: [1] Paras N. Prasad, Nanophotonics, Wiley-Interscience, 2004 [2] K. D. Sattler, Handbook of nanophysics, CRC Press, 2011 [3] Paras N. Prasad, Introduction to Nanomedicine and Nanobioengineering, Wiley, 2012 [4] C. Louis, O. Pluchery, Gold Nanoparticles for physics, chemistry and biology, Imperial College Press 2012 [5] Challa S. S. R. Kumar, Biofunctionalization of Nanomaterials. Wiley 2005
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
dr hab. inż. Joanna Olesiak-Bańska, prof. PWr (joanna.olesiak@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 Fizyka w nanoskali
Name of subject in English Nanoscale physics

Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT

Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2010W, W03ANB-SM2010L
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		15		
Number of hours of total student workload (CNPS)	50		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	2		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)	1,3		0,7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Fundamentals of optical spectroscopy.
2. Fundamentals of solid state physics.

SUBJECT OBJECTIVES

C1 To provide students with a general knowledge on physical phenomena occurring in inorganic nanostructures of various types.

C2 To provide students with a general knowledge on modern manufacturing techniques of various nanomaterials.

C3 To provide students with a general knowledge on modern applications of inorganic nanostructures.

C4 To provide students with a general knowledge on experimental techniques used for inorganic nanostructures investigations.

C5 To provide student with a ability to work in group at solving different experimental as well theoretical problems occurring during the laboratories.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 student knows the principles of different experimental techniques used for inorganic nanostructures analysis.

PEU_W02 student knows modern theories/technologies/ related with semiconducting nanomaterials.

PEU_W03 student knows and understands the principles of the experimental methods used in nanostructures investigations.

relating to skills:

PEU_U01 student can apply the principles of different experimental techniques to analyze semiconducting nanomaterials.

PEU_U02 student is able to analyze and critically evaluate experimental results obtained for spectroscopic data obtained for semiconducting nanomaterials.

relating to social competences:

PEU_K01 student understands the need to inform the public about the need to achieve the goals of sustainable development in technologies for the production of new materials, energy and environmental protection.

PEU_K02 student is able to work in a group, performing various roles including group leader.

PEU_K03 student is aware of the social role of the engineer.

PEU_K04 student is ready to critically evaluate his/her knowledge and received content.

PROGRAMME CONTENT

Lecture		Number of hours
Lec 1	Introduction to nanotechnology, nanostructures and discussion on the main civilization problems and market demands which stimulate nanotechnology development and defines new challenges for engineers.	2
Lec 2	Basic concepts of solid state physics and solid state spectroscopy	2
Lec 3-4	Basic concepts of physics of nanostructures: Excitons, Plasmons, Polaritons, Plextitons. Crystal vs. Quantum Box - electron energy diagrams, energy band-off sets, density of states, optical properties.	4
Lec 5	Basic concepts of physics and chemistry of inorganic nanostructures. Size effects, shape effects, surface effects.	2
Lec 6	Optical properties of nanocrystals: electron confinement, dielectric confinement, phonon confinement, core-shell structures, nanocrystals in matrix.	2

Lec 7	Methods of nanostructures growth: Chemical Vapor Deposition and Physical Vapor Deposition methods.	2
Lec 8-9	Methods of nanostructures growth: wet chemistry methods.	4
Lec 10-11	Nanocrystals applications in biology and medicine.	4
Lec 12-13	Nanocrystals applications in optoelectronics.	4
Lec 14	Main experimental methods used for nanostructures investigations. Setups, hands-on and deep theoretical insight. Photoluminescence, Photoluminescence Decay, Photoluminescence Excitation, Absorbance, Raman Spectroscopy.	2
Lec 15	Advanced experimental methods used for nanostructures investigations. Single nanocrystals spectroscopy. Super-resolution imaging.	2
….		
	Total hours	30

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

Laboratory		**Number of hours**
Lab 1	Introduction. Safety. Setups description.	2
Lab 2	Photoluminescence Decay of semiconducting nanostructures & Photoluminescence of up-converting nanostructures.	5
Lab 3	Photoluminescence Excitation of semiconducting nanostructures.	3
Lab 4	Absorbance of semiconducting nanostructures	5
	Total hours	15

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. Multimedia presentation N2. Lectures N3. Hands-on experiments discussed during lectures. N4. Scientific reports.

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 (lecture)	PEU W01-03	test
P2 (seminar)	PEU U01-02, PEU K01-04	student presentation

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] *Nanoscale Materials in Chemistry*, Second Edition, Edited by Kenneth J. Klabunde and Ryan M. Richards, 2009 by John Wiley & Sons, Inc.

[2] *Nanocrystals-Synthesis, Properties and Applications - Series: Springer Series in Materials Science*, Vol. 95, **Rao**, C.N.R., **Thomas**, P. John, **Kulkarni,** G.U. 2007

[3] *Semiconductor Nanocrystal Quantum Dots: Synthesis, Assembly, Spectroscopy and Applications*, Andrey L. Rogach, Springer 2008

[4] *Colloids and Colloid Assemblies: Synthesis, Modification, Organization and Utilization of Colloid Particles*, Frank Caruso, John Wiley & Sons 2006

[5] *Highlights in Colloid Science*, Dimo Platikanov, Dotchi Exerowa, John Wiley & Sons 2009

[6] *Colloid Science: Principles, Methods and Applications*, Terence Cosgrove, John Wiley & Sons 2010.

[7] *Functional Coatings: By Polymer Microencapsulation*, Swapan Kumar Ghosh, John Wiley & Sons 2006.

[8] *Nano-Surface Chemistry*, Morton Rosoff, Taylor & Francis, 2001.

[9] *Colloid Chemistry II*, Markus Antonietti, Springer 2003.

[10] *Applied Colloid and Surface Chemistry*, Richard Pashley, Marilyn Karaman, John Wiley & Sons 2005

[11] *Surface Chemistry*, A. Goel, Discovery Publishing House 2006.

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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 Optyka nieliniowa dla Chemików
Name of subject in English Nonlinear Optics for Chemists
Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: laboratory-obligatory / lecture-optional
Subject code W03ANB-SM21010W, W03ANB-SM2009L
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		15		
Number of hours of total student workload (CNPS)	50		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	2		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)	1,3		0,7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. General physics,
2. General Chemistry

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SUBJECT OBJECTIVES

C1 To provide students with general knowledge about the fundamentals of the theory of nonlinear light interaction with matter.
C2 To provide students with knowledge about main nonlinear optical phenomena.
C3 To provide students with knowledge about the main methods of study of matter using laser beams of short pulses and strong power.
C4 To inform students about the application of nonlinear optics achievements in science and technology.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 – Student has systematized knowledge within the physical basis of optical field interaction with matter.

PEU_W02 - Students can understand the physics of nonlinear light interaction with matter at the microscopic and macroscopic levels

PEU_W03 - Student knows and recognizes nonlinear optical phenomena of second and third-order

PEU_W04 - Student knows and understands measurement methods used to evaluate nonlinear optical properties of optical materials

relating to skills:

PEU_U01 – Student has the ability to propose optical material for fulfilling desired functionality of second and third nonlinear optical type.

PEU_U02 – Student has the ability to design measurement setup to measure fundamental nonlinear optical properties of a material

PEU_U03 Student is able to perform chosen experiments in the field of nonlinear optics

relating to social competences:

PEU_K01 – The student is able to do research and overview of scientific literature

PEU_K02 – The student has a knowledge of the importance and role of light in contemporary life and of materials interacting with light in a nonlinear fashion for the production of economical and useful devices for mankind

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Introduction to optics – light.	2
Lec 2	Basics of the light-matter interactions.	2
Lec 3	Harmonic oscillator approximation – linear effects.	2
Lec 4	Nonlinear optical medium, polarization, nonlinear optical susceptibilities.	2
Lec 5	Units, notation and conservation rules in nonlinear optics.	2
Lec 6	Phenomenological description of nonlinear optics phenomena. The most important second-order phenomena.	2
Lec 7	Phenomenological description of nonlinear optics phenomena. The most important third-order phenomena.	2
Lec 8	Detailed description of the second harmonic generation phenomenon.	2
Lec 9	Generation of sum and difference frequencies. Wave mixing processes.	2
Lec 10	Nonlinear refractive index, Kerr media	2
Lec 11	Generation of supercontinuum, solitons, and ultra-short pulses.	2
Lec 12	Nonlinear light absorption and emission – selection rules in nonlinear optics.	2
Lec 13	Modern materials for nonlinear optics.	2
Lec 14	Evaluation test of students' knowledge.	2

Lec 15	Second evaluation test of students' knowledge.	2
	Total hours	30

Laboratory		**Number of hours**
Lab 1	Linear electrooptic effect – Pockels effect	3
Lab 2	Optical Kerr effect	3
Lab 3	Second harmonic generation	3
Lab 4	Degenerate two-wave mixing	3
Lab 5	Optical phase conjugation	3
	Total hours	15

TEACHING TOOLS USED

N1. Lecture with use of multimedia presentation.
N2. Laboratory of nonlinear optics – group 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
P1 (lecture)	PEU_W01 PEU_W02 PEU_W03 PEU_W04 PEU_W05	Written test. Evaluation of test max. 100 pts 3.0 if 50-60 % pts 3.5 if 61-70 % pts 4.0 if 71-80 % pts 4.5 if 81-90% pts 5.0 if 91-95% pts 5.5 if 96-100 % pts
P1 (laboratory)	PEU_U01-PEU_U03, PEU-K01_PEU-K02	Evaluation of a single report of performed measurements

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] B.E. A. Saleh, M. C. Teich, Fundamentals of Photonics, Wiley, New York, 1999
[2] P. N. Prasad, Nanophotonics, Wiley-Interscience, New Jersey, 2004
[3] Pavel Chmela,"Wprowadzenie do optyki nieliniowej", PWN, Warszawa 1987
[4] A. Yariv, P.Yeh," Optical waves in crystals", Wiley 1984
[5] F. Kaczmarek, „Wstęp do fizyki laserów", PWN, Warszawa 1986
[6] S. Kielich, "Molekularna optyka nieliniowa", PWN Warszawa, 1977

SECONDARY LITERATURE:

[1] Photonics journal
[2] Original scientific articles available through the electronic literature database of the Main Library of WUST

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

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Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of CHEMISTRY

SUBJECT CARD

Name of subject in English: **Organic Electronics**
Main field of study (if applicable): **Advanced Nano and Biomaterials - MONABIPHOT**
Specialization (if applicable):
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W03ANB-SM2012W, W03ANB-SM2012S**
Group of courses: **NO**

	Lecture	**Classes**	**Laboratory**	**Project**	**Seminar**
Number of hours of organized classes in University (ZZU)	**15**				**15**
Number of hours of total student workload (CNPS)	**25**				**25**
Form of crediting	**crediting with grade**	crediting with grade	crediting with grade	crediting with grade	**crediting with grade**
For group of courses mark (X) final course					
Number of ECTS points	**1**				**1**
including number of ECTS points for practical (P) classes					**1**
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	**0,65**				**0,7**

*delete as applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Elemental mathematics: Analysis I and II, algebra
2. Elemental physics: Physics I and II
3. Fundamentals of physical chemistry

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SUBJECT OBJECTIVES

To provide students with a general knowledge of:
C1 Mechanism of electrical conductivity in organic materials
C2 Principles of operation of organic electronic devices
C3 Organic electronic materials and fabrication technologies
C4 Measurement methods used in characterization of organic electronic devices

C5 To gain experience in elaboration and presentation of state of the art knowledge, based on scientific publications

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01 - student knows the types and basic properties of typical organic electronic materials.

PEU_W02 - student knows the basics of the description of conductivity and electronic excitation in organic materials
PEU_W03 - student knows the principles of operation of diodes, transistors and photovoltaic devices.
PEU_W04 - student knows the methods of fabrication and characterization of organic electronic devices

relating to skills:
PEU_U01 student is able to interpret, elaborate and present a range of actual knowledge based on original scientific literature

related to social competences:

PROGRAMME CONTENT		
Lectures		**Number of hours**
Lec 1	Types and properties of materials used in organic electronics: crystals, polymers, molecules	2
Lec 2	Basic description of phenomena occurring during absorption and emission of radiation	2
Lec 3	Basic description of electrical conductivity in organic materials	2
Lec 4	Fabrication methods: vacuum, solution-based, Langmuir-Blodgett	2
Lec 5	Light emitting diodes - principles of operation and materials	2
Lec 6	Photovoltaic devices - principles of operation and materials	2
Lec 7	Field effect transistors - principles of operation and materials	2
Lec 8	Electronic devices built from single molecules, memories, optoelectronic devices	1
	Total hours	**15**
Seminar		**Number of hours**
Proj 1 - Proj 7	Student presentations on a selected topic from the field of organic electronics elaborated on the basis of original scientific reports	15
	Total hours	**15**

TEACHING TOOLS USED
N1. Lecture: traditional lecture or multimedial presentation N2. Seminar: students presentations

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_W01 - PEU_W04	Written essay on the given topic
F2	PEU_U01	Oral presentation
P= (F1+F2)/2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Köhler, A. and Bässler, H. (2015). Front Matter. In Electronic Processes in Organic Semiconductors (eds A. Köhler and H. Bässler).

SECONDARY LITERATURE:

[1] Jan Godlewski (2008). Wstęp Do Elektroniki Molekularnej.

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

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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 PEU_U01 –PEU_U03 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 PEU_U01 – PEU_U03 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; Presentation of research and analytical laboratories in the Faculty's units; 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 PEU_U01 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: - adsorbents in environmental protection and industry - alternative and renewable energy sources, renewable raw materials in industry, recycling technologies - technical security - medical and pharmaceutical chemistry - chemistry of coordination compounds - chemistry of fragrance compounds - physical chemistry of chemical processes and products - chemistry, engineering and technology of materials (polymer, carbon, ceramic, metallic) and composites - technologies of dispersed systems - catalysts and catalysis in industry - instrumental methods in chemistry - physicochemical description of simple and complex systems - 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 - industrial aspects of biotechnology - recycling of precious metals - issues of technological process and quality management, principles of investing and operating chemical technologies - modern chemical technologies - biotechnology development trends - basics of spectroscopic methods, - bioelectrochemical systems - issues related to sustainable development - 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: 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 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 PEU_U01 –PEU_U04 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 Card preparation: Piotr Rutkowski, piotr.rutkowski@pwr.edu.pl